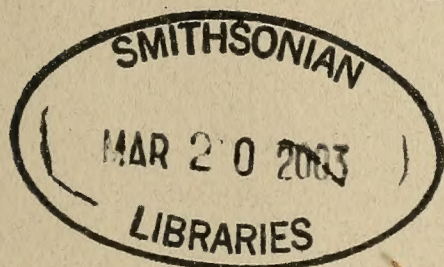


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Raymond E. Sicard, editor of *Journal of the Kentucky Academy of Science*, died on 2 October 2002. In October 1998 Dr. Sicard came to Pikeville College School of Osteopathic Medicine, Pikeville, Kentucky, where he was professor of anatomy and taught histology and embryology at the medical school. He received his A.B. in biology at Merrimack College, North Andover, Massachusetts, and his M.S. in zoology and Ph.D. in biological sciences at the University of Rhode Island. Before coming to Pikeville, he was at the University of Minnesota as research associate/assistant professor, Graduate Program in Molecular, Cellular, Developmental Biology, and Genetics. His primary research interests were in endocrine, neural, and immunological influence on forelimb regeneration in amphibians and in the selection of mechanisms for wound repair activated following traumatic injury. The author of well over 100 publications and active in the scientific community in eastern Kentucky, he was a member of many committees, civic organizations, and editorial boards.

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Growth, Weight, and Survival of Paddlefish, *Polyodon spathula*, Stocked at Two Densities in Channel Catfish, *Ictalurus punctatus*, Ponds

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ABSTRACT

Paddlefish, *Polyodon spathula*, are new to aquaculture in Kentucky. Since paddlefish feed on zooplankton, it is possible to culture them in ponds used for catfish aquaculture with little additional feed and aeration costs. Here we examined the growth, weight and survival in paddlefish cultured at two stocking densities (125/ha and 175/ha). There were two replicates per stocking density. The paddlefish were sampled several times during the growth period and all surviving fish were harvested after one year. Results of this study indicate that paddlefish at the lower stocking density (125/ha) are heavier than paddlefish cultured at the higher stocking density (175/ha). Mean growth rate and survival rate did not differ significantly between the two stocking densities. Preliminary economic analysis suggests that paddlefish contribute to catfish farm income by \$220/ha and \$151/ha, for 125/ha and 175/ha stocking density, respectively.

INTRODUCTION

Paddlefish, *Polyodon spathula*, is a filter feeding zooplanktivore, which has demonstrated a strong consumer acceptance in recent taste tests (Meyer pers. comm. 2001). Past research has clearly shown the aquaculture potential of paddlefish in ponds (Semmens and Shelton 1986; Tidwell et al. 1991). Current research at Kentucky State University is focused on polyculture of paddlefish with channel catfish, *Ictalurus punctatus*, in commercial ponds (Mims 2001). The term “polyculture” refers to the culture of multiple species in the same pond. Catfish ponds are usually eutrophic from the decomposition of excess feed and fish excrement. Such ponds support sufficient zooplankton to maintain paddlefish culture. Successful polyculture of paddlefish and catfish could increase profit margins for catfish producers.

Paddlefish research has been part of the mainstream aquaculture research in Kentucky

for the last 15 years. Production research has shown that paddlefish have a faster growth rate (6–10 lbs/year) in relatively cool Kentucky waters than in the Mississippi Delta area (Schardein et al. 2001). Pond culture of paddlefish is permitted in Kentucky; however, some states consider paddlefish to be a sport species and restrict its aquaculture. Consequently, Kentucky might have a competitive advantage in paddlefish aquaculture over major southern aquaculture states.

Here, we report field-trial results from one year of paddlefish polyculture in four commercial channel catfish ponds in Kentucky. Specifically, we sought to test for differences in weight gain and survival at harvest of paddlefish stocked at two densities in catfish ponds and to evaluate the farm-level economic impact of paddlefish aquaculture in Kentucky.

MATERIALS AND METHODS

Paddlefish fingerlings (mean weight 122.9 g; mean total length 37.4 cm) were stocked into

Table 1. Physicochemical characteristics of ponds containing paddlefish.

Parameter	Stocking density (per ha)		Sample size	P-value
	125 Fish	175 Fish		
Temperature (°C)	17.5 (± 8.7)*	17.6 (± 8.3)	16	0.92
Dissolved oxygen (mg/L)	7.8 (± 3.6)	8.0 (± 4.1)	16	0.96
pH	6.4 (± 0.4)	6.9 (± 0.5)	16	0.15
Nitrite (mg/L)	0.17 (± 0.04)	0.40 (± 0.05)	16	0.42
Non-ionized ammonia (mg/L)	0.02 (± 0.02)	0.02 (± 0.03)	16	0.92
Alkalinity (mg/L)	68.8 (± 25)	39.1 (± 25.8)	16	0.05

* Values are means ± 1 standard deviation.

2.0-ha commercial grow-out catfish ponds in western Kentucky (Graves County) on 14 March 2000. Four ponds, previously stocked with channel catfish fingerlings at 24,700/ha, were stocked with either 125 paddlefish fingerlings/ha or 175 paddlefish fingerlings/ha, with two replications per treatment. Catfish were fed once daily to satiation with a commercial catfish diet containing 32% crude protein. Individual weights and lengths of catfish were unattainable due to a multi-year, multi-batch production regime, which made tracking of survival rates and biomass from each catfish stocking prohibitively difficult.

Paddlefish were sampled in July and October 2000 and February 2001, for the first year using a 91.5-m seine (15.24-cm bar mesh). Weights and lengths were recorded for all sampled paddlefish. Ponds were harvested in March 2001 and paddlefish were counted, weighed, and measured. Dissolved oxygen and temperature were monitored daily using a YSI oxygen meter (YSI, Yellow Springs, Ohio). Emergency aeration was provided when dissolved oxygen fell to 3.0 mg/L, using a PTO-powered aerator. Total ammonia nitrogen (TAN), nitrite, pH, and alkalinity were recorded biweekly using a Hach Model FF-1A Field Kit (Hach, Loveland, Colorado). Non-ionized ammonia was calculated and recorded, based on Boyd (1990).

Average growth and survival parameters of paddlefish from the two stocking regimes were compared using standard *t*-tests. Any differences in water quality parameters were also investigated using the same methodology. A brief economic analysis was conducted to investigate the revenue contribution of paddlefish (\$/ha), net of stocking and labor expenses associated with paddlefish culture. Prices of paddlefish fingerlings and foodsize paddlefish

were derived from interviews with paddlefish producers, fingerling suppliers, and industry experts. We estimated a break-even cost of \$1.70/ paddlefish fingerling using Kentucky State University hatchery data derived by one of us (S. Dasgupta). We assumed market price paddlefish fingerlings to be \$2/head. Foodsize paddlefish price was kept at \$2.20/kg (live-weight). Wage rate for hired labor was kept fixed at the \$5.25/hr (minimum wage rate).

RESULTS AND DISCUSSION

There were no differences in mean temperatures, pH, dissolved oxygen, nitrites, and non-ionized ammonia in ponds between the 125 fish/ha and 175 fish/ha stocking densities (Table 1). There was a significant difference (*P* = 0.05) in average pond alkalinity between the two stocking densities. This indicates a difference in the buffering capacity of the ponds; however, the differences in alkalinity are unlikely to affect growth and mortality in paddlefish, particularly when the average pH levels do not differ significantly at the two stocking densities (Boyd 1990).

Growth rate (mean ± standard deviation) ranged from 8.27 ± 0.99 g/day in low-density ponds to 6.34 ± 0.58 g/day in high-density ponds (Table 2). Clearly, growth rate seemed higher with low-density stocking; however, small sample sizes precluded statistical analysis. There were significant differences between stocking densities in the mean harvest weight of the paddlefish. Fish weights(mean ± standard deviation) at harvest were 3.23 kg ± 0.56 kg and 2.52 kg ± 0.45 kg for sampled fish at 125 fish/ha and 175 fish/ha, respectively (Table 2). The survival rates were 53.6 % ± 13.58 % and 52.2 % ± 4.03 %, for the low-density and high-density ponds, respectively;

Table 2. Weights, harvest densities, survival and growth rates for paddlefish cocultured in channel catfish ponds.

	Stocking density (per ha)		Sample size	P-value
	125 Fish	175 Fish		
Average stocking wt. (kg)	0.120 ± 0.038*	0.126 ± 0.033	60	0.28
Average harvest wt. (kg)	3.23 ± 0.56	2.52 ± 0.45	59	0.00
Harvest density (head/ha)	67 ± 17	92 ± 7	2	—
Survival (%)	53.6 ± 13.6	52.2 ± 4.0	2	—
Growth rate (g/day)	8.27 ± 0.99	6.34 ± 0.58	2	—

* Values are means ± 1 standard deviation.

small sample sizes precluded statistical analysis.

Figure 1 shows changes in weight of paddlefish at different times of the growth cycle for the two stocking densities. Mean weight gain was similar at the two stocking densities from March 2000 to February 2001. Clearly, variability (the standard deviation) in weight was consistently higher at the lower stocking density.

Figure 1 shows a rapid weight gain in paddlefish stocked at 125 fish/ha, between February and March 2001. Mims and Clark (1991) discovered a sudden increase in average weight of paddlefish, overwintered in polyculture ponds. They reported that weight gain in paddlefish, stocked in ponds with catfish, averaged 71% over spring months. Zooplankton

have been found to be abundant during spring months. Onders et al. (2001) reported large numbers of zooplankton in late winter and early spring in Kentucky's reservoirs. Ivleva (1969) explained that spring and fall blooms of zooplankton are associated with a dying biomass of phytoplankton. This suggests that paddlefish have ample food supply in late winter/early spring months, which contributes to the sudden growth spurt.

Our study did not provide any information on potential effects of paddlefish on growth and survival of catfish in the polyculture ponds. Hence, we can only show the additional income that paddlefish might contribute to a commercial catfish farm.

Some advantages of paddlefish polyculture with channel catfish include: 1) paddlefish do

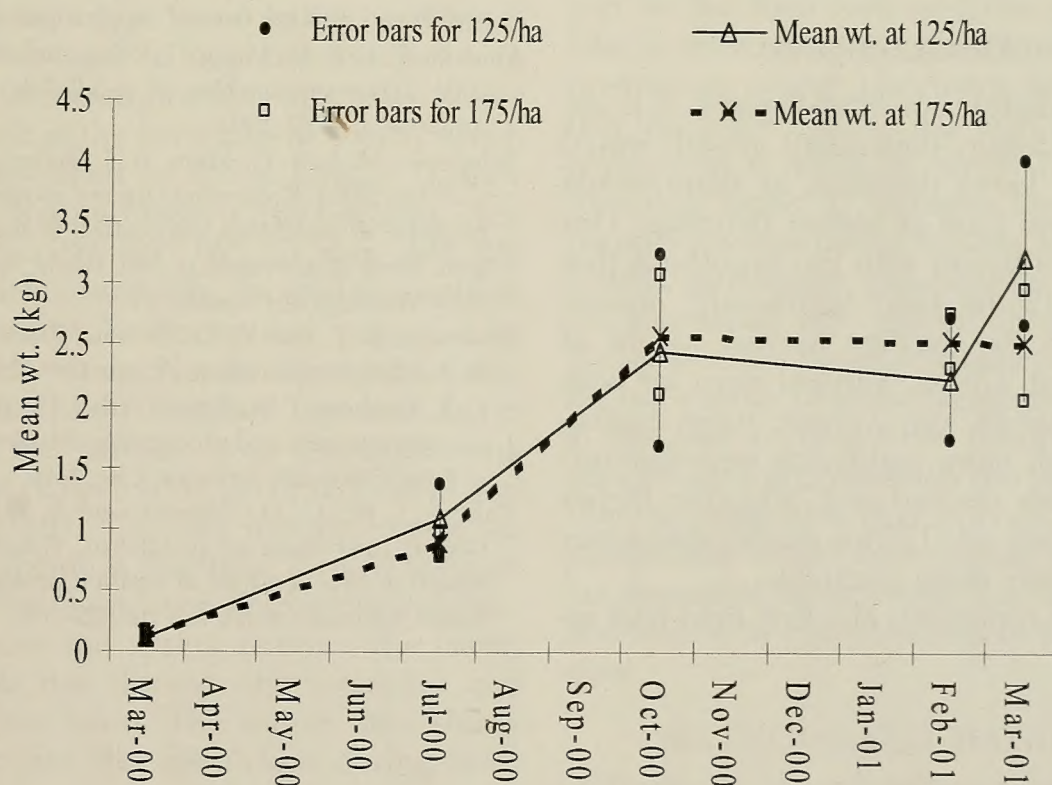


Figure 1. Seasonal mean weights of paddlefish stocked at two densities (125/ha and 175/ha) in catfish ponds between March 2000 and March 2001. Data are presented as mean ± standard deviation of weight at each observation.

not require additional prepared feed and additional aeration, management or labor during the growing season and 2) paddlefish do not require additional capital investments. The only costs associated with paddlefish are the cost of fingerlings for stocking and the additional labor cost at harvest in order to sort paddlefish from channel catfish. Paddlefish are relatively docile and most are easily captured in one seine-haul through a catfish pond. Field trials from commercial 2-ha ponds have demonstrated that it took two individuals no longer than 30 minutes to remove paddlefish from catfish after a seine haul. We estimated a maximum of one hour of labor sorting paddlefish from catfish after harvesting a 2-ha pond.

The average stocking and labor costs of paddlefish are $125/\text{ha} \times \$2.00/\text{head} + 1 \text{ hr} \times \$5.25/\text{hr}$ (or $\$255.25/\text{ha}$) and $175/\text{ha} \times \$2.00/\text{head} + 1 \text{ hr} \times \$5.25/\text{hr}$ (or $\$355.25/\text{ha}$), for the 125/ha and 175/ha stocking densities, respectively. Using mean harvest weight and survival rate for the two stocking densities (Table 2), the expected revenues from paddlefish ($/\text{ha}$) were computed to be $\$476.10/\text{ha}$ and $\$506.44/\text{ha}$, for the 125/ha and 175/ha stocking densities, respectively. Hence, the expected net returns for paddlefish were evaluated to be $\$220.85/\text{ha}$ and $\$151.19/\text{ha}$, for the 125/ha and 175/ha stocking densities, respectively.

CONCLUSIONS

Since paddlefish are filter-feeders, it is expected that density-dependent growth would be higher at lower densities, as there would be less natural food at higher densities. Our results are consistent with the hypothesis that stocking at 125/ha yield significantly heavier foodfish than the average harvest weight of fish stocked at 175/ha. Survival rates for both stocking densities, on average, were equivalent. Although more paddlefish were harvested from ponds stocked at 175/ha, the higher operating costs at 175/ha made the lower stocking density more profitable.

This study represents the first field trial in-

roducing paddlefish into commercial channel catfish ponds. While the results show the feasibility of producing small quantities of paddlefish, further research is needed to evaluate the impact of pond management on growth and survival rates of catfish and to identify optimal paddlefish biomass capacity in channel catfish ponds.

ACKNOWLEDGEMENTS

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The Effects of Phosphorus Enrichment on the Phytoplankton Community of a Karst Lake

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ABSTRACT

The impact of nutrient enrichment on lakes and streams has been well established but less is known about how nutrient enrichment affects temporary aquatic systems. During 1998, the impact of phosphorus additions in Chaney Lake, a temporary karst wetland, was assessed using plastic-sided mesocosms amended with K_2HPO_4 (3 experiments). The dominant phytoplankton communities shifted over time in Chaney Lake, with cyanobacteria and chrysophyte genera usually common throughout the study period. Results from the enclosure experiments indicated that nitrates and ammonia were significantly higher in the enclosures with additional phosphate during one experiment but the added phosphate had no effect during the other two. The high nutrient concentrations with low elemental ratios indicate that nitrogen is actually the limiting nutrient in this system. Future work should focus on bacterioplankton dynamics that may be influencing the response of the phytoplankton communities.

INTRODUCTION

A wetland's hydrology and geology can have major influences on its biological and chemical characteristics. Most karst areas are formed on carbonate rocks such as limestone, dolomites or gypsum. A major force in shaping karst terrenes is the dissolution of the limestone bedrock by CO_2 -rich groundwater, resulting in caves, underground rivers, sinking streams and sinkholes. There is typically little surface water in karst areas but, in some basins, geological characteristics such as impermeable layers in the subsurface can give rise to surface water features such as the karst lake or "polje" which was first described by Cvijic (1893). Chaney Lake State Nature Preserve (89 hectares, elev. 177.2 m; lat. $36^\circ 53' 05''$ N; long. $86^\circ 25' 16''$ W) is such a karst lake, located in southern Warren County, Kentucky and managed by the Kentucky State Nature Preserves Commission. The lake is situated on chert layers separating the surface from the underlying cave system (Crawford et al. 1987; Groves and Crawford 1991). The lake fills and drains via estavelles, openings that have formed through fissures in the chert layer. During the relatively wet winter and spring seasons, the caves' water levels rise through the estavelles and flood the lake basin. The waters then slowly drain back into the subsurface during drier

summer months. Chaney Lake is normally flooded between the months of January and August. During this period Chaney Lake can expand to over 1.5 km in diameter.

During the flooding period, the water column supports a diverse zooplankton community (Kelley et al. 2000) but, like many temporary aquatic environments, little is known about the structure and function of the planktonic producers that can be a very important part of the food web in these systems. This lake is situated in an agricultural region and preliminary water chemistry tests indicated that the water column has high nitrate levels, perhaps as a result of runoff from the surrounding farms. If nitrogen levels are high, phosphorus may be the limiting nutrient in the system and future phosphorous runoff from the watershed may change species composition or biomass in the phytoplankton. We conducted a series of three enclosure experiments in the lake to assess the possible impact of phosphorus enrichment on the phytoplankton. We hypothesized that corrals with added phosphorus would show higher algal biomass (as measured by chlorophyll *a*) and a shift to dominance by cyanobacteria in the water column.

METHODS AND MATERIALS

There are several different habitats in and around Chaney Lake that can be identified based on the dominant vegetation and, in

³ Corresponding author.

some cases, water chemistry (Kelley et al. 2000). We chose to conduct this study in an open marsh area because it holds water longer than any other habitat within Chaney Lake. *Polygonum pennsylvanicum*, *Cephalanthus occidentalis*, and *Proserpinaca palustris* dominated the emergent vegetation in this area and the average depth of the water in this section was approximately 35–45 cm when Chaney was completely flooded.

Ten enclosures, each 1 m³, were constructed with ½ inch PVC piping. Plastic was wrapped around the sides of the enclosures and tied at the corners. The corrals were anchored in the lake and the bottoms sealed with sediment from the lake bottom. After 5 days of equilibration, phosphorus in the form of K₂HPO₄ was added to five randomly chosen corrals. The amount of phosphorus enrichment was calculated by multiplying the highest level of the soluble reactive phosphate levels from the previous year's water chemistry surveys by the volume of water in each corral (a mean of 0.4 mg/L over the three experiments.) Three separate experiments in early spring (Experiment 1, March 12 through April 12), early summer (Experiment 2, May 21 through June 23) and late summer (Experiment 3, July 31 through August 20) were conducted. Sampling was done weekly for five weeks, except for the last experiment which had to be concluded after three weeks because of the lake drying.

Multiple whole-water samples (12 L) were taken every 5 days from each enclosure and the sample was concentrated by pouring the water through a 10 µm phytoplankton net and then allowing the organisms to concentrate at the bottom of a polypropylene sample bottle. Filtrate was returned to the enclosure. Water samples for nutrient chemistry were taken in 250 mL sterile polyethylene bottles and for chlorophyll analysis in one-liter sterile polyethylene bottles. Depth and physical parameters such as temperature, specific conductivity, dissolved oxygen percent, dissolved oxygen, pH, and turbidity were measured on site with an YSI 4250 (Yellow Springs Incorporated). The chlorophyll samples were taken back to the laboratory and subsamples were filtered through 0.47 µm Whatman GF/F filters. The filters were stored in plastic petri dishes and frozen at –20°C for later fluorometric analy-

sis. For nutrient determination, water was immediately filtered through 20 µm filters and concentrations of reactive phosphate, nitrates, ammonia and ammonium were measured using the HACH model DREL 2010 Portable Water Chemistry Apparatus. Chlorophyll was analyzed using methods specified by Wetzel and Likens (1991) and EPA method 445.0. The filters were thawed and then ground using a Teflon pestle attached to a motor (500 rpm, 1 min) in 90% acetone. The slurry was steeped for 24 hours at 4°C and then centrifuged at 1000 rpm for 5 minutes. The supernatant was analyzed for direct chlorophyll *a* concentrations corrected for phaeopigments. In experiment one, the chlorophyll *a* analysis was conducted using a Shimadzu DR-3, RF-540 fluorometer at excitation of 440 nm and emission of 660 nm. However, because of equipment failure of the RF-540, the chlorophyll samples for experiments two and three were analyzed by the Turner Design TD-700 fluorometer for direct concentration by the Welshmeyer non-acidification method at 436 nm excitation and 680 nm emission.

Phytoplankton samples were preserved with M3 preservative and stored for future analysis. Cell enumeration was performed using an Olympus BX40 System Microscope. Approximately 10% of the total sample volume was counted to identify the dominant genera. Algae were identified using Lee (1980) and Whitford and Schumacher (1973). The physical and chemical parameters between the treated and non-treated enclosures were analyzed with discriminate function analysis (DFA) and analysis of variance (ANOVA). The alpha level used for significance was 0.05. All statistical analysis was performed on SYSTAT 7.0.1.

RESULTS

In the first experiment, Bacillariophyceae (diatoms) and Cyanophyceae (blue-green algae) were the most common groups present in the phytoplankton. *Anacystis*, *Microcystis*, and *Eunotia* were the dominant genera numerically (in this and all following cases dominance refers to cell densities not biomass). In the enclosure experiment, *Anabaena* numbers increased slightly, as did *Eunotia*, but there were no significant differences between the control and phosphorus-enriched enclosures

Table 1. Shannon-Weaver diversity index (H) and equitability index (J) scores.

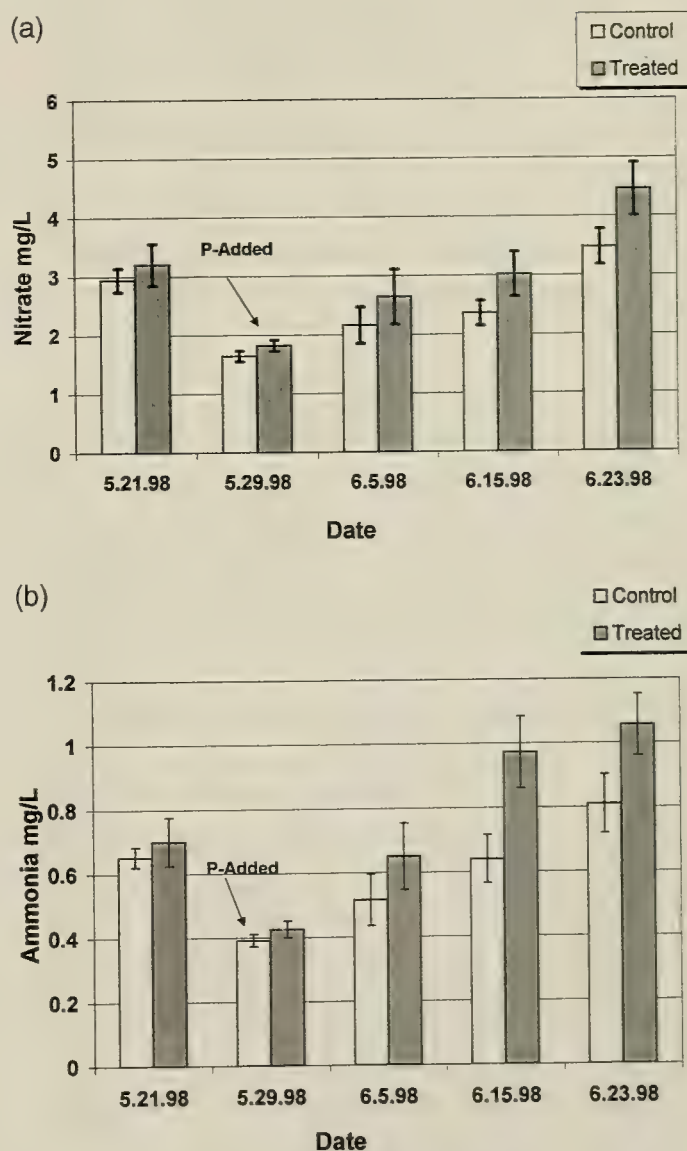
Experiment dates	Control		Treated	
	H	J	H	J
12 March–12 April	1.81	0.67	1.94	0.72
21 May–25 June	1.80	0.69	1.87	0.69
31 July–20 August	2.51	0.84	2.41	0.80

in taxa densities or in total chlorophyll ($P > 0.05$). The Chlorophyceae, *Planktosphaeria* and *Closterium*, were also present in the enclosures and neither seemed affected by phosphorus treatment ($P > 0.05$). Shannon-Weaver diversity indices (H) were very similar between treatments (Table 1). There were no significant differences in any of the measured water chemistry parameters between treatments. Phosphorus levels were initially higher in the treated enclosures after phosphorus addition (mean = 0.6 mg/L vs. 0.5 mg/L) but there were no significant differences in phosphorus levels among the control or treatment enclosures by the next sample date (7 days later). Nitrogen to phosphorus ratios also changed after phosphate addition (Table 2).

During experiment 2, *Anabaena* species dominated the phytoplankton along with two species of *Mougeotia*, one species of *Zygnema*, two species of *Oedogonium*, and one species of *Hyalotheca*. There were also two species of the chrysophyte *Dinobryon*, and the chlorophyte *Planktosphaeria*. Diatoms, specifically *Eunotia* and *Pinnularia*, were also present during this period. Both *Anabaena* and *Oscillatoria* numbers responded slightly to phosphorus enrichment in the experimental enclosures; but their densities and total community chlorophyll were not altered significantly by phosphorus treatment. None of these taxa responded to the phosphorous addition ($P > 0.05$) and neither the Shannon-Weaver diversity index (H) nor the equitability index (J) indicated great differences between control and treated enclosures (Table 1). Concentrations of nitrates ($F = 5.972$, $P = 0.0013$) and ammonia ($F = 4.144$, $P = 0.007$, $df = 3$) and turbidity ($F = 8.329$, $P = 0.005$, $df = 1$) differed significantly between the control and treated enclosures (Figures 1a and 1b). Ending phosphorus concentrations were between 0.9 and 1.4 mg/L in all of the control and treatment enclosures.

Table 2. Nitrogen to phosphorus elemental ratios in Chaney Lake between 12 March and 20 August 1998.

Experiment	Date	Control	Phosphorus-enriched
1	12 March	11:1	11:1
	18 March	6:1	8:1
	26 March	8:1	12:1
	5 April	16:1	13:1
	12 April	14:1	13:1
2	21 May	3:1	4:1
	29 May	4:1	6:1
	5 June	4:1	4:1
	15 June	4:1	6:1
	23 June	4:1	5:1
3	31 July	4:1	6:1
	4 August	5:1	5:1
	20 August	6:1	6:1

Figure 1. Nitrate (a) and ammonia (b) concentrations. Data are means (± 1 standard error) from Experiment 2 (21 May–25 June 1998).

In experiment 3, the phytoplankton community was dominated by *Anacystis*, *Oscillatoria*, *Oedogonium*, *Mougeotia*, *Scenedesmus*, *Closterium*, *Eunotia* and *Pinnularia*. Again, there were no significant differences in taxa densities and chlorophyll and nutrient concentrations between treatments ($P > 0.05$). The Shannon-Weaver diversity index also indicated the same level of diversity between the two treatments (Table 1). Phosphorus levels reached their lowest levels recorded in Chaney Lake by the end of this experiment (around 0.4 mg/L for all enclosures.)

DFA was performed to evaluate differences between the individual variables with respect to phosphorus-enrichment over the entire study period. This analysis indicated that there were overall differences between the enriched and control enclosures (Wilks' $\lambda = 0.74$, $F = 2.96$, $df = 12$ and $P = 0.0014$). The classification matrix indicated that a total of 72% of cases in the row categories were classified correctly into columns. The jackknifed classification matrix indicated that a total of 64% of the variables can be placed in correct categories. The classification functions indicated the highest difference between the groups in nitrates and ammonia, consistent with the ANOVA findings in experiment 2.

DISCUSSION

In analyzing the organisms in the control enclosures (reflecting the marsh's natural environment), there was low algal diversity (Gary Dillard, pers. comm.). In fact, this system was mostly dominated by two genera of blue green algae, *Anabaena* and *Oscillatoria*, the green algae *Mougeotia*, *Zygnema*, and *Oedogonium*, and the diatoms *Synedra*, *Eunotia* and *Pinnularia*. Algal composition and community structure were not altered in response to a significant phosphorus-addition, which suggests that the phosphorus levels in the marsh area of Chaney Lake may not be limiting to phytoplankton. Previous water chemistry surveys at Chaney Lake had revealed high levels of nitrate, at least in certain areas of the lake (Kelley et al. 2000), so we had hypothesized that phosphorus was likely to be limiting algal growth in this system.

However, during these experiments, levels of phosphorus in all enclosures were never below 0.4 mg/L. Secondary nitrogen limitation of

algae is a common phenomenon in many freshwater systems (Hecky and Kilham 1988). The stoichiometric balance of physiological needs of algae for various nutrients led to the proposal of the "Redfield Ratio" (Redfield 1958) and many more recent experiments have focused on the balance of nutrient needs in phytoplankton (e.g., Sterner et al. 1995). However, analysis of the nitrogen to phosphorus elemental ratios during 1998 suggests that nitrogen may be the limiting nutrient for algae in this system. Le et al. (1994) conducted a similar experiment with large mesocosms containing whole plankton communities from mesoeutrophic Calder Lake. A range of nitrogen and phosphorus concentrations and nitrogen to phosphorus ratios were tested to examine coupling between the biomass of planktonic bacteria and that of phytoplankton under nutrient-limited and nutrient-surplus conditions. In this experiment, addition of phosphorus without nitrogen stimulated the growth of planktonic bacteria but did not stimulate the growth of phytoplankton. The suggestion is that nitrogen and phosphorus conditions are mutual factors affecting algal-bacterial coupling, which elicit independent but parallel increases in bacterial and phytoplankton densities (Le et al. 1994). We did not assess bacterial numbers or biomass in this experiment, but a similar "uncoupling" may have occurred in our enclosures.

The focus of the Le et al. (1994) study involved a perennial lake environment that is different from Chaney Lake. The next step in studying this temporary wetland would be to investigate the role of planktonic bacteria and periphyton. Further research is needed to identify the bacterioplankton and periphyton communities and to determine whether there is a relationship between availability of nutrients and these groups of organisms. Chaney Lake's unique hydrogeology offers an opportunity to study an environment with both aquatic and terrestrial characteristics that is very different from either of those individual habitats. Quantification of the role of bacterioplankton and periphyton in Chaney Lake and how they relate to nutrient availability need to be investigated further.

ACKNOWLEDGEMENTS

We thank Dr. Douglas M. McElroy for his advice in statistical analysis, Dr. Gary E. Dil-

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Comparison of Two Numeric Dating Techniques, OCR and ^{14}C , Employed at a Buried Archaeological Site (15HL21) in Harlan County, Kentucky

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ABSTRACT

As part of a geoarchaeological investigation conducted at a buried, multi-component, prehistoric habitation site located along the banks of the Cumberland River in Harlan County, Kentucky, a recently-developed numeric dating technique, the Oxidizable Carbon Ratio (OCR) procedure, was selected (1) to develop a chronological framework within which both natural and cultural processes could be interpreted and (2) as an independent verification of radiocarbon dates obtained from a previous phase of archaeological investigation. The OCR method measures the site-specific rate of organic carbon biodegradation in charcoal or soil humic material as a ratio of total organic carbon to readily oxidizable carbon. The OCR dates compare extremely well with the ^{14}C dates, they are consistent with the site's cultural chronology as evinced by the temporally diagnostic artifacts recovered, and they illustrate the accuracy that can be obtained with this new method.

INTRODUCTION

During spring 1996 a geoarchaeological investigation was conducted at the Whitfield Site (15HL21), a buried, multi-component, prehistoric habitation site located along the banks of the Cumberland River in Harlan County, Kentucky (Figure 1). Previous archaeological investigations identified a series of relatively low intensity occupations spanning the late Archaic through Woodland cultural periods, roughly 5500 to 1200 years before present (Pace 1995). These cultural-bearing strata were buried by natural levee deposits that formed part of a first terrace (T-1) paralleling the northeast side of the river at this location (Josephs 1997). The site was located along a section of the river where the US Army Corps of Engineers planned to construct an artificial levee as part of extensive flood control measures implemented throughout the Upper Cumberland River Valley. Because these projects are federally funded, National Historic Preservation legislation requires that the proposed areas of impact undergo various levels of archaeological assessment prior to the start of construction.

One of the primary goals of any geoarchaeological investigation is the development of a temporal context within which the natural and cultural processes that have affected a site can be assigned and interpreted (Waters 1992). A

recently developed dating technique, the Oxidizable Carbon Ratio (OCR) procedure, was selected as the preferred numeric method for the geoarchaeological investigation because of its thorough accountability of soil system processes (Frink 1992, 1994, 2001). Not only would the OCR dates provide the necessary age control for the accumulation/formation of the first terrace (T-1), they would also serve as independent verification for radiocarbon dates obtained from a previous phase of archaeological excavation.

THE OXIDIZABLE CARBON RATIO (OCR) PROCEDURE

The biological recycling of organic carbon is fundamental to nearly all living organisms. While some forms of organic carbon, such as fresh organic matter, are rapidly recycled, other more resistant forms, such as humic acids and charcoal (carbonized organic matter), are recycled at a much slower rate (Frink 1992, 1994). The OCR dating procedure measures the site-specific rate of the biodegradation of organic carbon as it occurs in soil humic material or charcoal. The effect of the biochemical degradation is measured by a ratio of the total organic carbon to the readily oxidizable carbon in the soil sample. Over time, the reserve of readily oxidizable carbon decreases at a greater rate than that of the total organic



Figure 1. Location of the Whitfield Site (51HL21) plotted on physiographic map of Kentucky (from McGrain 1983).

carbon (Frink 1992, 1994). Spatial and environmental factors are the principal variables affecting the accuracy of the OCR procedure. The rate of biochemical degradation varies according to the specific physical and environmental context from which the sample is taken. Precise recording of sample provenience and mean annual climate data promotes the accuracy of the results. An age estimate is determined through a systems formula (Figure 2) that accounts for the biological influences of oxygen, moisture, temperature, carbon concentration, and the soil reactivity (Frink 1992, 1994).

The OCR dating procedure was developed by OCR Carbon Dating, Inc. (formerly the Archaeology Consulting Team), headed by Mr. Douglas Frink, of Essex Junction, Vermont. Although developed in New England, the OCR procedure has been used effectively in numerous environmental settings around the world. OCR Carbon Dating, Inc. maintains a current list of where, and by whom, the OCR procedure has been used; it can be accessed

through the company's website at members.aol.com.dsfrink/ocr/ocrpage.htm.

Unlike radiocarbon dating, the OCR procedure is not affected by the de Vries, Suess, Atomic Bomb, or carbon reservoir effects or by fluctuations of the earth's geomagnetic field. The OCR procedure can accurately date samples as young as one year; the maximum datable age limit has yet to be determined. Its standard error is less than 3% (Frink 1992, 1994).

Because it has yet to "stand the test of time," the OCR procedure does have its share of critics. It is receiving the same type of careful scrutiny to which any other new scientific idea would be, or has been, subjected. OCR Carbon Dating, Inc. continues to refine the procedure in order to maximize dating accuracy and consistency. A rigorous debate of the Oxidizable Carbon Ratio procedure can be found in the "Point/Counterpoint" section of the November 1999 (volume 17, number 5) issue of the *Society for American Archaeology Bulletin*. This article is also available online at

$$\text{OCR}_{\text{DATE}} = \frac{\text{OCR} \times \text{Depth} \times \text{Mean Temperature} \times \text{Mean Rainfall}}{\text{Mean Soil/Sediment Texture} \times (\text{pH})^{1/2} \times (\% \text{Carbon})^{1/2} \times 14.4888}$$

Figure 2. The Oxidizable Carbon Ratio (OCR) dating equation: a systems formula that measures the site-specific rate of the biochemical decay of carbonized organic matter in terms of its chronometric age.

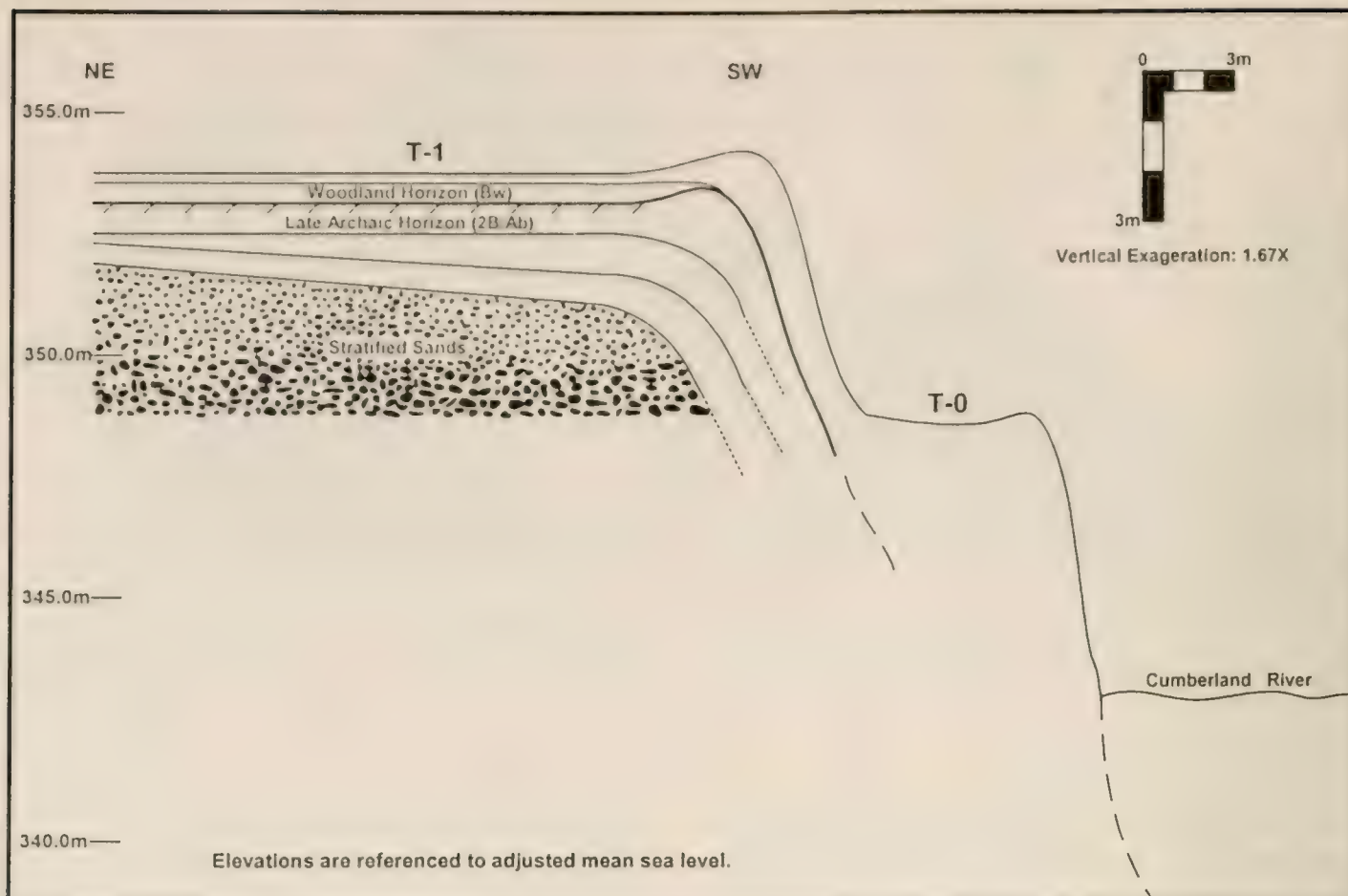


Figure 3. Profile of the Whitfield Site (15HL21) depicting the pedostratigraphy of the terraces (T-1 and T-0) and the location of the buried cultural horizons.

www.saa.org/publications/saabulletin/17-5/saa18.html

PHYSICAL SETTING

The Whitfield Site is located on a first terrace (T-1) ca. 10 m above the normal level of the Cumberland River (Figure 3). The cultural components are buried by overbank levee deposits. The backside of the levee slopes gently away from the crest, while the riverward side forms a steep scarp descending ca. 5 m to the surface of the active floodplain (T-0). The stability of the river's straight channel pattern in the immediate vicinity of the Whitfield Site, as well as the steepness of the terrace scarps, is directly related to its position along the base of a steep, northwest-southeast trending ridge (Figure 3). A bedrock bluffline directly across (southwest) from the site has virtually halted channel migration/lateral accretion in that direction (Josephs 1997).

The formation of the first terrace (T-1) corresponds well with the channel-overbank scenario, a classic fining-upward alluvial sequence in which fine-grained, top-stratum facies over-

lie coarse-grained, bottom stratum facies (Boggs 1995; Daniels and Hammer 1992; Ritter 1986; Waters 1992). At the Whitfield Site, the top-stratum deposits of very fine to fine sandy loams and sandy clay loams overlie bottom-stratum deposits of culturally sterile, well-stratified fine to coarse sands. The contact between the top and bottom stratum facies occurs over an interval of 2 to 3 m below the surface of T-1 (Josephs 1997).

Soil borings advanced into the actively aggrading floodplain (T-0) revealed an unstratified accumulation of greater than 3 m of medium to coarse loamy sand and sand. The presence of decomposing twig and leaf mats (representing former, short-lived flood plain surfaces [Bettis 1994]), dispersed historic artifacts, industrial slag, and coal fragments indicates formation of this land surface during the Historic Period (Josephs 1997). This landform reflects the tremendous increase in sediment supplied to the area's streams over the past 100 years as a result of intensive coal and timber extraction (McBride and McBride 1996).

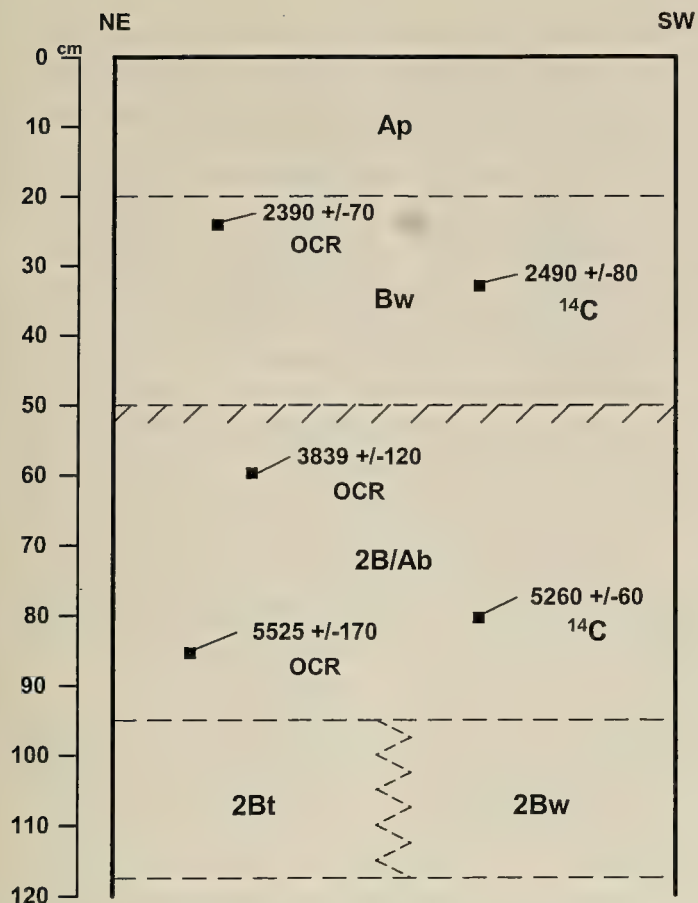


Figure 4. Chronostratigraphic soil profile illustrating the comparison between the OCR dates and the radiocarbon dates. The horizontal relationships are not to scale.

RESULTS

Three 200-gram samples of organically-enriched fill, collected from hearth and midden (trash pit) features, were submitted for dating by the Oxidizable Carbon Ratio procedure. Two of the samples were collected from a fine sandy loam (2B/Ab) paleosol, one from an overlying, fine sandy loam, cambic (Bw) soil horizon (Figure 4). Based on two previously-obtained radiocarbon dates (conventional method) and the recovery of temporally diagnostic artifacts (projectile points and pottery sherds), the 2B/Ab horizon contained the site's Late Archaic component while the Bw horizon contained the younger Woodland component (Josephs 1997; Pace 1995).

The earliest date obtained was an OCR date of 5525 ± 170 B.P. (ACT#2477) from feature fill recovered ca. 85 cm below the existing terrace (T-1) surface in the lower portion of the 2B/Ab horizon. This compares well with a radiocarbon date of 5260 ± 60 B.P. (Beta-81076) from a sample of wood charcoal collected from ca. 80 cm below surface (Figure 4). A second sample of feature fill recovered from

the upper portion of the 2B/Ab horizon, at a depth of 60 cm, produced an OCR date of 3839 ± 120 B.P. (ACT#2476). All of these dates fall securely within the Late Archaic, 6000 to 3000 years before present (Bense 1994), and serve to bracket the accumulation/formation of the buried soil within this 3000-year time span (Josephs 1997).

The third OCR sample retrieved from the upper half of the overlying Bw horizon, ca. 25 cm below ground surface, produced a date of 2390 ± 70 B.P. (ACT#2474) that falls within the Early Woodland Period (3000 to 2000 years before present). A sample of wood charcoal from the lower half of the Bw horizon, collected roughly 8 cm below the OCR sample, produced a radiocarbon date of 2490 ± 80 B.P. (Beta-81075), also within the Early Woodland Period (Figure 4) (Bense 1994). Once again, these dates are consistent with age ranges typically assigned to the cultural artifacts found within the horizon and confirm a 3000-year time frame for the cumulative and non-cumulative development of the buried paleosol (Josephs 1997).

CONCLUSIONS

The OCR dating of organically-enriched feature fill from the Whitfield Site (15HL21) successfully accomplished its geoarchaeological objectives: (1) defining a temporal framework within which natural and cultural site-formation processes could be interpreted; and (2) verifying radiocarbon dates obtained during the earlier Phase II archaeological investigation. The OCR results compare favorably with the radiocarbon assays, and all five numeric dates are quite consistent with the cultural chronology as established from the temporally diagnostic artifacts. In the case of this study from southeastern Kentucky, the OCR method proved to be an uncomplicated, cost-effective, and highly accurate numeric dating option when compared to the conventional radiocarbon procedure used during the Phase II archaeological investigation.

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NOTES

References to Kentucky in *The Butterflies of Eastern United States and Canada, with special reference to New England* (1889) by Samuel Hubbard Scudder.

—Old Kentucky records of 10 species of butterflies were recently discovered in S.H. Scudder's 1889 *The Butterflies of Eastern United States and Canada, with special reference to New England*. These had not been included in Covell's 1999 *The butterflies and moths (Lepidoptera) of Kentucky: An annotated checklist*. Recently I had occasion to study the rare and superb three-volume *The butterflies of eastern United States and Canada* published privately in 1889 by the noted Massachusetts entomologist Samuel Hubbard Scudder. Since its focus was on the northeast, I had not considered it an important source of information for my long-term study on the butterflies and moths of the Commonwealth (Covell 1999). To my great surprise I found references to Kentucky in the coverage of 10 species, including a fascinating account of the spread of the European Cabbage White, *Pieris rapae*, from its first discovery in Canada in 1860 to the time of publication of the book. The treatment of each of the 10 species presented below consists of the following: (i) genus and species names followed by the author's name as it appears in Covell (1999); (ii) scientific name for the species as used by Scudder (1889), if different, in parentheses; (iii) English (common) name generally used today; (iv) page reference to species in Covell (1999); (v) quotation concerning the species from Scudder (1889), with volume and page reference from that work; and (vi) my comments. The order of treatment and scientific names follow Covell (1999), as this agrees with the current classification of North American butterflies. Excellent modern treatments of these species can be found in Opler and Malikul (1998).

1. *Autochton cellus* Boisduval & LeConte. (*Rhabdoides cellus* [Boisduval & LeConte]). Gold-banded skipper (p. 63). "occurring throughout the southern states from Georgia to Arizona, and as far north as West Virginia and Kentucky." (III: 1855). Frequently found in the eastern mountains of Kentucky.

2. *Erynnis martialis* Scudder (*Thanaos martialis* [Scudder]). Mottled duskywing (p. 64). "Cumberland Gap, Ky. ([George] Dimmock)" (II: 1497). This Bell County record is an addition to counties listed in Covell (1999). This species is uncommon and very local throughout Kentucky.

3. *Polites peckius* Kirby. Peck's skipper (p. 65). "Kentucky (Brit. Mus.)." (II: 1686). Common to abundant statewide.

4. *Polites themistocles* Latreille (*Limochores taumas* Fabricius). Tawny-edged skipper (p. 65). "Louisville, Ky.

(Belknap, Mus. Yale Coll.)." (II: 1728). Common to abundant statewide.

5. *Amblyscirtes vialis* Edwards. Common roadside-skipper (p. 67). "Cumberland Gap, Ky. (Dimmock)." (II: 1585). Covell (1999) did not include Bell County in the distribution of this species, so it is an addition. Moderately common statewide in clearings and powerline cuts and along road edges.

6. *Pieris rapae* Linnaeus. Cabbage white (p. 69). "We have, however, two curious items: it is reported by Mr. C. R. Dodge as being destroyed by parasites in Louisville, Ky., in this year [1873], which implies that it appeared there at least the year before (probably M. Dodge's informant mistook the destructive southern cabbage butterfly for this." (II: 1183). In his account of the first discovery of this European import by William Couper in the vicinity of Quebec City, Canada in 1860 and its subsequent distribution, he mapped the known spread south and westward, showing Kentucky to be in its known range by 1875. The Dodge record, therefore, would be prior to its appearance in eastern Kentucky in 1875. Common statewide from early spring to late fall.

7. *Calycopis cecrops* Fabricius. Red-banded hairstreak (p. 73). "It is found from West Virginia and Kentucky southward." (III: 1822). Moderately common throughout the state.

8. *Callophrys grynea* Hübner. (*Mitoura damon* Stoll). Juniper hairstreak (p. 73). "Dimmock took it at Cumberland Gap, Ky." (II: 865). This locality is in Bell County, Kentucky, and constitutes an additional county record to those in Covell (1999). Common in April and July in groves of eastern redcedar, *Juniperus virginiana*, on which the larvae feed.

9. *Polygonia comma* (Harris). Eastern comma (p. 77). "occurs about Louisville, Kentucky (Belknap, Yale Coll. Mus.)." (I: 337). Common statewide.

10. *Euphydryas phaeton* (Drury). Baltimore checkerspot (p. 78). "[William Henry] Edwards also reports it from Kentucky;" (I: 695). Only a few colonies are now known for this very local species.

LITERATURE CITED. (1) Covell, C.V., Jr. 1999. The butterflies and moths (Lepidoptera) of Kentucky: An annotated checklist. Ky. State Nature Preserves Comm. Tech. Series 6. (2) Opler, P. A., and V. Malikul 1998. A field guide to eastern butterflies. Peterson Field Guides. Houghton Mifflin, Boston, MA. (3) Scudder, S. H. 1889. Butterflies of the eastern United States and Canada. 3 vols. Publ. by the author, Cambridge, MA—**Charles V. Covell Jr.**, Department of Biology, University of Louisville, Louisville, Kentucky 40292-0001.

APPENDIX

Abstracts from the Kentucky Junior Academy of Science Meeting

The mission of the Kentucky Academy of Science is to encourage scientific research, promote the diffusion of scientific knowledge, and unify the scientific interests of the Commonwealth of Kentucky. This is accomplished, in part, through programs sponsored and encouraged by the Junior Academy of Science.

The Junior Academy holds a meeting annually at which precollege students have the opportunity to share their experiences in investigative science with their peers and with more seasoned science educators and scholars. This meeting provides an excellent opportunity through which KAS fulfills a portion of its mission by ratifying the efforts of these fledgling scientists and acknowledging their accomplishments.

The *Journal* also plays a role in this process by broadening the exposure afforded these ini-

tial experiences in scientific investigation. In this section, sample abstracts from last year's Junior Academy program are presented. Please share with us the celebration of these early steps in science by the student's whose work is summarized here. The Editorial Board of the *Journal* takes this opportunity to congratulate these students and their mentors. In addition, on behalf of the Academy's Governing Board, we encourage you to help advance the Academy's mission and to assist these student efforts by providing your encouragement and, if possible, mentorship in the development of projects and in the written and oral communication of project results.

Raymond E. Sicard, Ph.D.
Editor

Recognition of writing and communication skills

Beginning with the abstracts submitted for the 2003 Junior Academy meeting, abstracts will be reviewed and judged by a panel consisting of the journal editor, abstract editor, and chair of the Junior Academy. Criteria that will be assessed include editorial style and presentation of scientific content. We will be looking for abstracts that contain proper spelling, syntax, and grammar throughout. In addition, we will be evaluating how well the abstract communicates the essence of the studies reported: (i) a clear description of the problem or hypothesis to be tested, (ii) an indication of how the study was conducted, (ii) presentation of analyzed data supported by indications of statistical significance, and (iv) an indication of the contribution made by the study. The top

three abstracts will be highlight at the beginning of this section in future issues of the *Journal*. In addition, these students will be awarded a one-year membership in the Academy.

Although no awards are yet being made, we wish to note that the abstracts appearing in this issue that were written by the following students best represent what we will be seeking. We encourage them and the other student authors to continue to refine their writing skills.

- | | |
|------------------|----------------|
| Erin Finger | David Meigooni |
| Stephanie French | Sudip Saha |
| Jiayi Liu | Lisa Soper |

Abstracts Submitted from the 2002 Kentucky Junior Academy of Science Meeting

Edited by Robert J. Barney

BEHAVIORAL & SOCIAL SCIENCES

The effects of light to medium marijuana abuse on short-term memory in teenage smokers. EVAN BOYER, duPont Manual High School, 120 W. Lee St., Louisville KY 40208.

This experiment was created with the hope of determining the effects of light to medium (weekly to monthly) marijuana smoking on short-term memory. It was hypothesized that the effects would be negative. A survey was created consisting of several questions relating to the subject's drug usage, as well as the subject's age and gender. A short-term memory test was attached to the survey, in which the subject wrote down a series of letters that were shown to them for four seconds after the letters had been shown. A statistical analysis revealed that those that smoked marijuana scored on average approximately 0.70 points (out of 12) higher than those that did not smoke, which would lead to the conclusion that smoking marijuana is, in fact, beneficial to the user, as far as short-term memory is concerned. However, the control group (those that did not smoke) was significantly larger than the smoking group, 86 controls to 46 smokers. Therefore, a conclusion may be that the group that smokers may have been, on average, already smarter than the nonsmoking group, even before they started smoking. However, this aspect was not testable. Therefore, it seems that smoking marijuana may not be detrimental to short-term memory.

The effect of Stroop stimuli and task performance on subject ERPs. JOYCE CHARLESWORTH, Seneca High School, 3510 Goldsmith Lane, Louisville, KY 40220.

One typically finds that people are faster when naming color patches than when naming colors of written words, particularly when the word written is incongruent (e.g., green). This is because the process of reading is automatic and interferes with the given task of color identification. Automatic responses are those that are difficult to alter and are products of practice. In 1935, John Ridley Stroop used what is known as the Stroop task to explore properties of interference and automatic behavior. In this task, participants must look at a color word written in an incongruent color and identify the color of ink. In Stroop's work, he found subjects averaged 47 seconds longer to correctly identify 100 incongruent colors than just the color patches. The problem with Stroop's work is that while it shows the effect of interference, the impact of interference on the brain is not seen. This study used brain waves to further examine interference. The brain waves were recorded in response to three sets of stimuli—color words written in black ink, blocks of color and the incongruent color words. Each stimulus appeared in blocks of approximately 40 occurrences. The ERPs (event-related potentials, the sections of the brain waves in response to the stimulus) were then extracted and compared. In this

study, gender was looked at as a possible reason for variance in the brain wave. The results of this study were consistent with the hypothesis that females would have an earlier peak, showing they were better at overcoming interference.

Do standardized tests reflect problem solving ability? DANIEL T. CORNETT, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

This project was designed to quantitatively test whether or not there is any correlation between standardized test scores and problem solving ability. This experiment was done because many people say that these tests do not provide an accurate representation of a student's scholastic abilities. Many also claim that these tests do not measure any sort of thinking ability, such as problem solving skills. Thus, this testing was done to see if a student's standardized test scores would reflect upon their problem solving ability. Each test subject was asked to complete one level of the puzzle game Sokoban. The subject was timed on how long it took them to complete the puzzle. The subject was then asked for their standardized test scores. This data could then be used to draw conclusions about whether there is a correlation between problem solving ability and standardized test scores. It was found that there was a strong correlation between the test subject's PSAT scores and their time on solving the puzzle. A subject with a higher PSAT score would be more likely to have a much faster time than a subject with lower PSAT scores. Unfortunately, not enough data could be collected about the other standardized tests to draw any conclusions about them.

Neuromusicology—how music affects daily activity. RA-SEAN CRAWLEY, JENNIFER HENDERSON and JASON BRATCHER, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Sleep has been a problem for many people. Music has helped people relax and concentrate while working or studying. This experiment was constructed to find if music had a direct affect on the quality of sleep received. Five musical compact discs (CDs) of five genres each were used in this experiment. Twenty subjects were given the CDs and asked to listen to them while they slept at night. In the morning, they were given a survey from which the results were gathered. The goals of this experiment were to find any connection with the genre and the quality of sleep. Each genre gave us a different average of the subjects' quality of sleep. It theoretically states that there is a correlation between style of music and the quality of sleep. This experiment also hoped to examine the relationship between genre of music and the stress factor of the human subjects being tested. The experiment was not designed to choose the best genre of music but to see

how each genre affects the daily activities and/or thought processes of an individual.

The implications of age in relation to the risk assessment of immunosuppressive medication in composite tissue allografts. ERIN FINGER, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Composite tissue allograft (CTA) procedures have not become a standard method for surgical reconstruction because of the recognized risks posed by the immunosuppressive drugs required to prevent allograft rejection. The age of CTA candidates directly affects their assessment of the risks and benefits of CTA procedures due to their changing perception of their body image. The objective assessment of the relative degree of risk that healthy subjects of different ages are willing to accept to receive seven reconstruction CTA procedures would provide a solid foundation upon which to continue introducing new reconstructive modality into the clinical arena. A standardized questionnaire technique was used to conduct the study, which consisted of 14 questions for 7 different transplant scenarios: full face, partial face, larynx, single hand, double hand, foot, and kidney. Volunteers of two populations of people, senior citizens (people age 65 or older) and adolescents (people ages 13 to 18), were asked the extent to which they would trade years of their life in exchange for different transplant procedures. To increase the likelihood of a valid response, visual aides were used to demonstrate the changes that would be produced by the transplant for selected scenarios. The results of this study indicated that the younger population would choose to give up more of their remaining life to receive a transplant, indicating that they would accept a lower chance of rejection to prevent allograft removal and resulting damages to physical appearance. The population of senior citizens would accept less risk than the adolescent population as a whole to undergo any of the seven CTA procedures, but would accept a greater chance of rejection if the transplant would improve their quality of life without shortening their life span.

Interference and the Stroop effect. STEPHANIE FRENCH, duPont Manual High School 120 W. Lee St., Louisville, KY 40208.

The purpose of this experiment was to assess the degree to which a person has thoughts about irrelevant, distracting occurrences. The interference that automatic processing of words has on a required task, the naming colors, was explored. Interference refers to the tendency for performance to decline when confronted with numerous distracting stimuli. This occurs when a second irrelevant source of information requires a different response than that required by the relevant information. A variation of the classic Stroop task was presented to 50 adult subjects. Subjects were asked to quickly name the ink color of words in five experimental conditions. These conditions were color only, congruent words, incongruent words, nonsense words, and irrelevant words. The results indi-

cated that naming colors of incongruent words took longer than any of the other experimental conditions. The slower rate of naming colors of words denoting incompatible ink colors demonstrates the Stroop effect. It was also found that naming colors that were congruent with the words was faster than any of the other experimental conditions, including the control in which no words were present. It was surmised that subjects read the words despite the instructions to name the colors. Performance was slower for naming the colors of nonsense words and irrelevant words than for naming congruent colors and the color only condition. These results indicate that the unconscious activation of meaning is not limited to the color word. A comparison between male and female performance revealed no significant difference. It can be concluded that although attention is focused on one aspect of the task, conscious thoughts about the printed word cannot be avoided. The Stroop effect suggests that people are not always in complete control of the information to which they attend. In order for psychological processes to be effective, interference from extraneous sources must be controlled.

Medical discrimination. DANIEL MAKELA, duPont Manual High School, 120 W. Lee Street, Louisville, KY 40208.

The purpose for conducting this study was to determine if racial discrimination exists in healthcare throughout the United States. The MedPAR file, which contains records from all Medicare patients, provided data for the experiment. A computer program was used to sort out specific ICD-9 codes with principle diagnoses dealing with chest pain. After the data was compared, the results showed that there was indeed a major difference between the low-tech and high-tech procedures. The percentage of blacks with chest pain out of the total patients was 12.2%. The top six high-tech procedures had low percentages of African-Americans ranging from 4.0% to 12.2%. However, some of the low-tech procedures had a much higher percentage of African-Americans from 9.5% to 14.9%. An unexpected result was the sky-high percentage of African-Americans who received amputations. The percentages for the two amputation procedures were 26.9% and 20.0% for African-Americans. The conclusion to this experiment was that there is racial discrimination in the delivery of healthcare services to elderly patients. More specifically, African-Americans suffering from chest pain do not receive their fair share of high-tech surgical procedures.

Dreams and the power to perceive. MIRAJ M. SANGHVI, duPont Manual Magnet High School, 120 W. Lee St., Louisville, KY 40208.

This experiment was to determine if pictures could affect dreams. In this study, 100 people were asked to view a certain picture, which was provided, before they went to bed. Then in the morning, the survey takers were asked to complete a survey or questionnaire about the dream(s) they might have had. A person might have viewed four different pictures. These pictures included a wedding

cake, a war scene, a tiger cub, or a beach view. Each person was provided with one picture and then asked how it affected the dream. All of the pictures had a completion rate of approximately 20 of the 25 that were shown. This shows us that the pictures did have an affect on the dreams and that dreams could be controlled in a sense. However, this study wasn't able to get everyone to remember their dreams, and this caused some lost data. In addition, this experiment did not use color pictures or many people. This experiment should be expanded using more people, a controlled lab environment, color pictures, and a means of getting everyone to remember their dreams.

Relation of false memory creation to emotional content and mode of presentation of word lists. SHANNON TURNEY, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of this experiment was to determine whether emotional content and mode of presentation had any influence on the recall and recognition of words. PowerPoint presentations and audio CDs were created with 15 words on each, all connected in some way to one critical word that was not included in the presentations. There were two sets of word lists: one set that would likely elicit an emotional response, and another that most likely would not elicit an emotional response. Subjects were presented with two word lists "emotional" in nature, one aurally and one visually. Likewise, they were presented with two of the "non-emotional" type. After each word list was presented, the subjects were immediately given a recall test and asked to write down everything that they remembered from the preceding presentation. They were distracted for several minutes, and then given a written recognition test where they were asked to rate each word given to them as to whether it was presented, and their confidence in their answer. Overall, the critical word (not presented) was the most incorrectly remembered with 49% of subjects "remembering" it on the recall test, and approximately 83% "remembering" it on the recognition test. In the visual emotional content recognition test, 84% of the subjects believed that the critical words were presented when in fact they were not. The emotional audio test produced the lowest success rate of the recall tests and both non-emotional tests produced the lowest success rate in the recall tests. These results seem to indicate that emotional content and the presence of prompts are important in producing false memories.

BIOLOGICAL TOPICS

Symptom distress and gender differences in patients with advanced lung cancer. DEBORAH R. ERNST, Seneca High School, 3510 Goldsmith Lane, Louisville, KY 40220.

This study investigated the symptom distress and gender differences of 20 advanced lung cancer patients, 40% who were female. Subjects were interviewed by the Research Assistant at the James Graham Brown Cancer Cen-

ter. The Memorial Symptom Assessment Scale was used to evaluate symptom frequency, symptom severity, and symptom distress. Most frequent, severe, and distressing symptoms for females included lack of energy, difficulty sleeping, dry mouth, pain, difficulty concentrating, and feeling nervous. Most frequent, severe, and distressing symptoms for males included lack of energy, feeling drowsy, pain, shortness of breath, dry mouth, and worrying. Females reported three times as many psychological symptoms as males to be among the most distressing. Results supported the proposed hypothesis and suggest caregivers should consider the influence of psychological factors when addressing needs of female lung cancer patients and physical factors when addressing needs of male lung cancer patients.

Methyl-sulfonyl-methane and the reducing potential of the aging mosquito. JIAXI LIU, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

An increase in glutathione (GSH) can extend the life span of aging organisms. Methyl-sulfonyl-methane (MSM) could form cysteine (Cys), which in turn could be incorporated into GSH. To test this hypothesis, MSM was given to the yellow fever mosquito, *Aedes aegypti*. Newly emerged female adults were fed with 0.01% or 0.1% MSM in a 10% solution. Samples of 10 mosquitoes were collected, processed and analyzed spectrophotometrically by the DTNB method for GSH/Cys every 7 days, but more frequently near the end of the study. The results indicated that the GSH/Cys content increased two-fold 21 to 26 days after MSM was introduced and then dropped to the starting level by the 35th day. Although the 0.01% MSM group seemed to have a higher GSH/Cys level, statistically it was the same as the 0.1% group. However, feeding 1.0% MSM was extremely toxic. These results demonstrate that MSM is absorbed and converted to GSH/Cys, but the life span was significantly shorter.

The synaptic organization of the outer plexiform layer of the retina in mice with mutant calcium channels. JIE MA, 120 West Lee St., duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Neurotransmitters are specialized chemical compounds that serve as messengers in the central nervous system. Synaptic transmission of axons and dendrites to transport the neurotransmitter glutamate occurs first in the outer plexiform layer (OPL), then the inner plexiform layer (IPL) of the retina. Incomplete congenital stationary night blindness (CSNB2) is an X-linked disease induced by mutations in a voltage dependent L-type calcium channel (VDCC) gene. Normal transmission between photoreceptors and bipolar cells is dependent on the expression of L-type VDCCs in the OPL, which mediate calcium entry into photoreceptor terminals and subsequent glutamate release. This study seeks to discover the function of the calcium channel in the system of information processing in the retina by examining the development of the retina in transgenic C57BL6/J (or B6) mice with no VDCCs in

the photoreceptors. Three proteins expressed in the retina, bassoon, PKC, and recoverin, and were each tested on three genotypes (normal, heterozygous, and null) of adult C57BL6/J (or B6) mice. Results show that the recoverin data showed no significant change except decreased expression of recoverin proteins along the OPL. However, PKC proteins were expressed past their usual termination at the OPL, to the ONL. Irregular elongation of the postsynaptic dendrites of the bipolar cells was thus observed. Such deformity witnessed in the PKC and recoverin experiments are indicative of the effect of L-type VDCCs in the retina. It was hence concluded that without neurotransmitters' presence, abnormal synaptogenesis results in the OPL. The hypothesis was thus corroborated.

The effect of distal and proximal space between insulator and promoter reported by luciferin expression. RATANAPHONE MEKMAYS, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Drosophila experience a mutation with an insertion of the gypsy DNA. The purpose of this experiment is to test the effect of space between insulator (gypsy DNA) to the promoter region. It was hypothesized that the further away the insulator, the greater transcriptional stimulation. Three categories of *Drosophila* were gathered. One was WWL1, which did not have the gypsy DNA, WWL3.04, which consisted of the insulator 400 base pairs away from the promoter, and WWL3, which consisted of the insulator next to the promoter site. The *Drosophila* were fed luciferin and there was a RLU reading to detect insulator-promoter stimulation. From the results, when the insulator is distal from the promoter, there is a greater stimulation of transcription compared to when there is no gypsy DNA and when the insulator is proximal to the promoter. The results prove the hypothesis and in conclusion, transcription is stimulated best when insulator is distal from the promoter region.

A study of the effects of peppermint oil on the symptoms of seasonal affective disorder. LISA MUDD, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Seasonal affective disorder or SAD is a condition in which people seem to weaken during the colder months of the year. Characteristics include a lack of energy and the ability to concentrate, increased appetite, hypersomnia, and withdrawal from family and friends. A study was conducted to determine if peppermint oil has an effect on SAD. The study was conducted using 15 women between the ages of 20–35 years who had been previously diagnosed with SAD. Of the 15 women, 3 groups were formed: a control group, a light therapy group and a peppermint therapy group. The light therapy and peppermint therapy groups were asked to do their respective therapies for 3 hours each day for 2 weeks, while the control group was asked to do nothing to decrease their symptoms during this time period. After analyzing the data, it was found that the light therapy group experienced 91.4% improve-

ment in their symptoms, peppermint therapy experienced 85.7% improvement, and the control group experienced no improvement. Therefore, it was shown that peppermint oil does have an effect on the symptoms of seasonal affective disorder.

Survivability of transplanted pancreatic islets transfected with the VEGF gene. NATHAN PARTHASARATHY, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

A mammalian expression system for the production of human vascular endothelial growth factor-1 (VEGF), has been developed in Chinese hamster ovarian—K1 cell lines (CHO). CHO cells were transfected with a new mammalian compatible plasmid containing the CMV promoter and zeocin antibiotic sensitivity. Subconfluent CHO cells were transfected with this new vector and FuGENE6 reagent (1:6), and single colonies were picked by zeocin antibiotic selection after 4–5 weeks of culture in special plastic dishes. Single colonies were carefully isolated and further cultured in 24-well plates. Both media supernatants and cell extracts were used for dot blot analysis. Specific antibodies to human VEGF produced in goat were used. Preliminary analysis of dot blot analysis showed several positive spots demonstrating that VEGF is both secreted and intracellularly produced. Future work on large-scale production of VEGF can be produced from these colonies and pure protein can be easily isolated by exploiting its carboxy terminus six-histidine residues using nickel agarose column. My project has successfully produced human VEGF in a mammalian cell line (CHO) and an unlimited supply of VEGF can be produced from these cells for further vascular research.

Expression of rat neuroglobin cDNA in BL21 (DE-3) competent cells, a protein related to stroke and brain damage. SUPRAJA PARTHASARATHY, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

An efficient *Escherichia coli* expression system for the production of rat neuroglobin (Ngb) protein has been constructed. Complementary DNA (cDNA) coding Ngb was inserted into an inducible bacterial expression vectors, pRSET A, B and C. After the plasmid with Ngb cDNA introduced into *E. coli*, they were induced with isopropyl 1-thio-beta-D-galactopyranoside (IPTG). The recombinant Ngb was purified by sonicating the bacterial cells and treating them with Bug Buster reagent. The clarified supernatant was partially purified and its purity was tested by SDS-PAGE electrophoresis. Cloning and expression of Ngb in bacteria offers an excellent unlimited source of rat brain Ngb and further work can be continued for its protein structure and antibody production. Future work on large-scale production and crystal structure of Ngb will help to design new drugs targeting this vital brain protein. The project successfully produced rat neuroglobin protein in pRSET vector A because it was in frame. This efficient bacterial system is capable of producing an unlimited supply for further research on stroke and hypoxic conditions.

Photodynamic effect in *Stentor coeruleus*. VERONICA RODRIQUEZ, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The photodynamic effect is a phenomenon in which certain microorganisms, especially bacteria, are damaged or killed when treated with fluorescent dyes and subsequently exposed to light under aerobic conditions. Death may be the result of DNA damage, protein damage, or membrane damage. *Stentor coeruleus* (blue-green ciliated protozoans) were exposed to 0.00025% concentrations of acridine orange and eosin Y, and 0.000025% concentrations of methylene blue, and then exposed to UVA and UVC light. The motility and morphology of the *Stentor* were recorded at 15 minute intervals. *Stentor* exposed to UVC alone tended to have a lower survival rate than those exposed to UVA alone. As the photodynamic effect occurred in the *Stentor*, the organisms lost their original trumpet shape and changed into ball-like shapes; as the *Stentor* began to die they got pale in color and began to disintegrate. UVC light in combination with the dyes had the greatest effect on *Stentor*. Acridine orange, both alone and in combination with UVC and UVA, was the dye that affected *Stentor* the most. UVC light had a more detrimental effect on *Stentor* than did UVA light.

Changes in vasoconstriction and vasodilation in rat aorta due to hypercholesterolemia. SUDIP K. SAHA, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Hypercholesterolemia is a clinical condition in which excess amounts of cholesterol are in the blood and plasma. It has been linked to cardiovascular disease. The aorta is the main trunk of the systemic arterial system and is designed to deliver blood to the rest of the arterial system. The purpose of this study was to examine the effects of hypercholesterolemia on vasoconstriction and vasodilation of rat aorta. One group of rats was fed a high (1%) cholesterol plus cholic acid (0.5%) diet for three weeks while another group of control rats were fed a normal diet. The aorta in each rat was isolated and divided into aortic rings, then studied using tissue force analyzers and a Grass polygraph machine. Vasoconstriction was tested using successively increasing concentrations of phenylephrine. Vasodilation was tested using successively increasing concentrations of acetylcholine or sodium nitroprusside. Phenylephrine elicited concentration-dependent contraction of both normal and hypercholesterolemic aortic rings. However, there was no significant ($P < 0.05$) difference in vasoconstrictive response between the two groups. Acetylcholine and sodium nitroprusside elicited concentration-dependent dilation of both normal and hypercholesterolemic aortic rings. In addition, no significant differences in the responses to acetylcholine or sodium nitroprusside between the two groups were apparent. These findings suggest that excess cholesterol intake does not significantly change vasoconstriction and vasodilation (endothelium dependent and independent) in rat aorta.

tcMMEP evidence of descending motor tract maturation in postnatal rats. ZOE ZHANG, duPont Manual High School 120 West Lee Street, Louisville, KY, 40208.

The purpose of this study is to determine the maturation timetable for the motor tracts in the ventral lateral finiculus (VLF) by measuring the onset latency and amplitude of tcMMEP. It is hypothesized that the maturation of the myelin will quicken the transmission of the neural impulses, shortening the latency and increasing the amplitude of the tcMMEP. Twenty-one non-anesthetized female Sprague-Dawley rats were tested every half postnatal week from 1 to 8. The body weights and lengths were recorded each testing time, as were the stimuli threshold, the onset latency and peak-to-peak amplitude. One, 3, 5, and 8-week old rats were perfusion fixed with paraformaldehyde and soaked in a 30% sucrose solution. Slices 16 μm -thick were cut from the spinal cord of each and stained with luxol fast blue and RIP. The RIP staining shows that oligodendrocytes are present in the VLF as early as one week, but the lightness of the luxol fast blue staining presents evidence of immature myelin sheaths. Comparison between the latency, conduction velocities, amplitude, and stimulation threshold of neonatal and adult subjects support the hypothesis. By week five, the latency, amplitude, and stimulation threshold plateau and do not differ from that of an adult animal, suggesting motor pathway maturation.

BOTANY

Promoting lichen growth on dry stone fences. GEORGINA A. ANDERSON, Lincoln County High School, 60 Education Way, Stanford, KY 40484.

Dry stone fences are an important part of Kentucky's heritage. Recent efforts to preserve and restore dry stone fences have led to an interest in mixtures that will promote lichen growth to enhance the beauty of these fences. Some of these mixtures include milk and yogurt, potato water, and manure. The purpose of this study was to determine which of these mixtures promoted the quickest and most lichen growth on rocks used in dry stone fences. The milk and yogurt mixture encouraged the most lichen growth relatively quickly. If left on their own, lichens grow only 0.1 to 10 mm per year. A milk and yogurt mixture is recommended to anyone interested in encouraging lichen growth to enhance the beauty of his or her dry stone fence.

The effect of stomatal behaviors on plant growth. HUY T. LE, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

It had been established that the grow hormone, abscisic acid (ABA), plays a major part in restricting stomatal closures. Recent experiments show the existence of a root-to-shoot communication that sends ABA from the root to the leaves of the plants when there exist signs that the soil is drying out. This leads to a new theory that soils and its water storage capacity has an effect on stomatal behaviors. The purpose of this experiment was to investigate the ef-

fect of different soils on stomatal behaviors and whether or not these behaviors affect plant growth. It was hypothesized that soils do affect stomatal activities and that the more time stomata are open, the faster the plant growth. The results suggest that stomata behaviors were the same for all three soils. However, plants from potting soils grew the fastest and plants in clays grew the slowest. It was concluded that the soils did not have an effect on stomatal behaviors and that stomatal behaviors did not have an effect on plant growth. It is recommended that the research be repeated with better-controlled environment, and more careful and frequent observations.

Cytoplasmic streaming in *Nitella*. MONICA SUMME, Notre Dame Academy, 1699 Hilton Drive, Park Hills, KY 41011.

The purpose of the first segment of this experiment was to determine the effects of calcium chloride and EDTA on cytoplasmic streaming in the green alga *Nitella*. Chambers were constructed of silicon culture gum sandwiched between microscope slides. A filament of *Nitella* was placed inside the chamber, and covered in Alga-Gro®. The same procedure was repeated with a CaCl_2 solution and an EDTA solution. The cytoplasmic flow was observed through a microscope, captured in Videopoint®, and analyzed to find the velocities of individual particles moved by the streaming. Average velocities for cells in calcium chloride and EDTA did not differ from those of the control, probably because the calcium ions and EDTA did not enter the cell. The flows were designated right or left with respect to the observer. The right and left flow rates in control cells were not statistically different. In CaCl_2 , however, flow rates for right and left were different, as they were in EDTA. The reason for this is not known. Another segment of the experiment investigated the impact on flow rate of a 60° tilt. In the tilted cells, results for the upward flow and the downward flow were statistically different. In addition, these differed significantly from rate of flow in control (horizontally placed) cells.

CHEMISTRY

Electrochemical detection for capillary electrophoresis with ion selective Ag/AgCl electrodes. JAY ANDERSON, duPont Manual High School, 120 W. Lee Street, Louisville, KY 40208.

Capillary electrophoresis devices seem like they would be the perfect candidates for becoming a "lab on a chip" because of their inherent small size. Unfortunately, the optical means of detection commonly used, such as lasers, violate the traditional "lab on a chip" definition because of portability. Capillary electrophoresis with electrochemical detection is able to clearly discern between different targets within the analyte even with smaller sample volumes. Ion selective electrodes, which only respond to certain ion groups, are an effective method of electrochemical detection. The adaptation of commercial ISE electrodes to a custom microfluidic device is not very feasible or conducive to the "lab on a chip" idea so custom ISEs

are the next choice. Adding a coating of AgCl to a Pt wire by means of electrocyclic voltammetry produced chloride specific ISEs that were then tested potentiometrically. According to the Nernst equation, $E = (E^\circ) + (0.059/n) \log \{C\}$, with n being a constant, the behavior of chloride specific electrodes should change by 60 mV by every factor of ten that the concentration of chloride ions changes. The custom Ag/AgCl ISEs were tested with five solutions with a constant NaNO_3 concentrations of 0.1 M and a varying concentration of NaCl ranging from 0.1 M to 10^{-5} M. The mean mV change between each concentration of the three electrodes for concentrations 0.1 M to 10^{-4} M was 52.5 mV or about 6.5 mV from the desired behavior. It was determined that the electrode response becomes erratic and inaccurate at concentrations of 10^{-5} and below.

Is biodiesel fuel a viable alternative to diesel fuel? BRIAN GOODIN, duPont Manual High School, 120 W. Lee Street, Louisville, KY 40208.

This experiment was conducted to determine if biodiesel fuel, made from vegetable oils, is a viable replacement for fossil fuels. Three different oils were used. Sunflower oil, peanut oil, and corn oil were all turned into biodiesel fuel through transesterification, a process of turning one ester into another. Once each form of biodiesel fuel was made, all four fuels were put through three tests to compare the biodiesel fuels to diesel fuel. The first test was a flammability test. This was the time it took for a 1 cm³ sample of the fuel to completely burn off a watch glass. The second test was to test the viscosity of the fuels. This was accomplished by dropping a one-gram ball bearing into 100 cm³ of the fuel and recording the time this took. The third test was finding the caloric value of each fuel. To do this 100 cm³ of water was placed into an aluminum can and the can was heated using the fuels. The amount of fuel it took to raise the water temperature 5°C was recorded and converted into kilojoules per liter. We found that it burns for a little shorter time than diesel fuel, but has almost identical viscosity. The caloric value, which is how much energy can be produced, was lower in the diesel fuel than it was in the biodiesel fuel. This means that biodiesel fuel produces more energy per liter, suggesting that it may also be more fuel-efficient.

Optimizing protein crystal growth. ANDREA MASON, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of this experiment was to modify the standard NASA method of growing excelsin crystals to produce improved crystals in the presence of gravity. Crystals of average dimensions (0.19 by 0.14 mm) were grown by the standard method. The first new apparatus slowly dripped water into a container containing a 5% salt solution. This surrounded a dialysis membrane bag in which the crystals were formed. The excelsin crystals that resulted were larger (0.32 by 0.23 mm), more numerous and of more geometric morphology than crystals obtained by the standard method. The growth change was statistically

significant ($P = 0.02$) and the size suited to X-ray study. Other processes are being tested at this time in additional attempts to slow the absorption of water and promote crystal growth. In one case, a membrane bag containing a protein/salt solution has been placed in a beaker of distilled water and sodium polyacrylate added to form a gel. It was hypothesized that this super absorbent chemical would slow the absorption of water and promote crystal growth. The average measurements of the crystals obtained by this method were only 0.05 by 0.03 mm, showing that in its present form this method is not useful. Two additional methods are being tested, both of which utilize absorbent cloth to slow the water absorption into the membrane bag. At this time, no crystals have been produced by these two methods.

Improving the performance of nanocrystalline solar cells and discovery of a new electrochemical cell. ALLISON MORRIS, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Nanocrystalline dye-sensitized solar cells are photochemical cells that synthetically recreate the process of photosynthesis. Control cells were studied and voltages of the order of 200 mV produced. Previously unreported oscillating behavior was observed. The major purpose of this research was to attempt extension of the lifetime of these cells, which are thought to expire mainly due to the drying of the liquid electrolyte. This research focused on ways to keep the electrolyte in the chain of reactions longer by preventing evaporation. The first method used was sealing the periphery of the cell. Experiments were performed using nail polish and silicon culture gum as sealants. The nail polish interfered with the electrical connections and therefore was not a good sealant, but the silicon culture gum successfully extended the lifetime of the cell from about 0.5 to 4.5 hours. The following attempts to extend the useful cell lifetime centered around improving the electrolyte by incorporating it in a gel. When sodium silicate was used in combination with the electrolyte, the mixture solidified quickly and absorbed the dye from the titanium dioxide, so it was quickly rejected as a possible gel to use. Next, a substance that formed a gel in ethylene glycol had to be found. Agarose, agar and gelatin were tested. The agarose did not make a gel, so it was not used in the cell. Agar made a loose gel in ethylene glycol, and when this mixture, in combination with the electrolyte, was used in the cell, voltage was produced for less than 10 minutes. When a mixture of gelatin/ethylene glycol and iodine was used in the cell, a new electrochemical cell was discovered. This cell produced an initially higher voltage than the control cell. The voltage rose with time. Amazingly, its output was unaffected by illumination. The cell behaved in the same way even without dyes requisite for the operation of traditional nanocrystalline photosensitized cells.

Tear film lipid composition deterioration with age and its effects on the progression of dry eye disease. CAN-

DACE QUIRE, Seneca High School, 3510 Goldsmith Lane, Louisville, KY 40220.

Research was done to find a possible cause for dry eye disease so an effective treatment could possibly be created. Tear film was collected from a pool of people that were between 14 and 18 years old, and the lipid and protein content of the tear film was studied. Schirmer strips were used to collect the tear film, and an attenuated reflectance was used to discern the contents. The data received from the younger age group was then compared to that of the older age group, which contained people from ages 46–53 years. The lipids and proteins in the tear film both diminished in the older age group, but the ratio of proteins to lipids stayed the same. This supports that lipids do in fact diminish with age, but the proteins diminish also; it's inconclusive whether or not lipids are the cause for dry eye syndrome to appear.

COMPUTER SCIENCE & MATHEMATICS

Testing and optimization of MOSIX in various Linux environments. AARON CANARY, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Strengthening Linux processing power is not easy. The Linux kernel does not support higher-class multiprocessor server machines. The 2.2.x kernel is able to run on most four-processor machines; the long-awaited 2.4.0 kernel SMP enhancements will be able to run on machines with up to 16 processors, matching what Microsoft Windows 2000 Advanced Server can do, but 16 processors is still too few for power-hungry tasks. Clustering could be the solution. Clustering offers two main advantages: scalable power and redundancy/high availability (HA). Most cluster solutions offer load balancing and switching around damaged nodes. One such Linux clustering solution is MOSIX. The MOSIX beta version was tested and failed migrate processes to other nodes in a RedHat 6.0 network in environment due to NIC driver incompatibilities with MOSIX kernel. The full 1.12 version of MOSIX in a Windows NT with virtual machine software failed due to IP address complication. MOSIX 1.12 failed to compile kernel correctly due to change in source kernel files in RedHat 7.2 system.

Development of a model relating funding and success rate in social intervention programs. FRANK Z. GUAN, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

This experiment sought to create a model capable of accurately predicting the success of a social intervention program based on the funding given. The Michaelis-Menton model, which is normally used to predict enzyme reaction rate, was found to have been applicable to a social intervention program encouraging breast-feeding by Dr. Scott Bagley, when relating the degree of intervention to success rate. We believe that altering this model could produce a new model relating funding to success. The experiment managed to develop a preliminary model that could predict success with reasonable accuracy. However,

attempts to procure sufficient data with which to test the model failed, preventing further expansion of the experiment. The practical uses of such a model are limitless. In the modern social-democratic state, many state intervention programs either fail to receive enough funding or are overfunded. A working model could allow for better allocation of financial resources towards these programs, which are designed to diminish social ills, and thus create a healthier society for all.

Determining whether the human eye can distinguish between TIFF and JPEG images. NIKITA GUPTA, duPont Manual High School, 120 W. Lee St, Louisville, KY 40208.

The purpose of the study was to determine if a difference between digital images obtained as TIFF (Tagged Image File Format) files and those files compressed into different levels of JPEG (Joint Photographic Expert Group) compression can be distinguished qualitatively by the human eye. Twenty-eight subjects were given surveys and they were shown pairs of digital images, one the original TIFF image and the other a high, medium, or low JPEG compression level of the original image. These three comparisons were done for three different pictures. The subjects were asked to choose which image in each pair they preferred based on contrast, resolution, color saturation, sharpness of detail (edges), and overall. A chi-square test of the total number of times the TIFF image was chosen over the JPEG images in the overall category indicated that the observed frequencies did not differ greatly from the expected. No agreement between the subjects was indicated by kappa statistics of the comparison factors and the possible combinations of choices. It was predicted that no difference would be noticed by the subjects. The null hypothesis, that the TIFF images would be easily distinguishable, could be rejected because no significant differences resulted. Based on the extreme file size variations between the TIFF files and all three JPEG files (the TIFF files being 20–100 times larger than the JPEG files), JPEG files can be used with no difference distinguishable to the human eye, thus saving on computer memory and expensive digital cameras.

Artificial intelligence. JOHN A. HANAUER, duPont Manual High School, 120 W. Lee St, Louisville, KY 40208.

Artificial intelligence refers to a machine's capacity to mimic human thought and behavior. A few of these technologies include expert systems, computer game AI, fuzzy logic, and robotics. In a continuation of last year's program, a more efficient algorithm for solving an eight-tile puzzle game was found. The first algorithm iterated through every combination of possible solutions until the correct solution is found. The new algorithm utilizes "Manhattan" mathematics theory, to take the distance of each displaced tile and rate each solution based off this number. A solution path with a greater distance was less likely to be the correct solution. This way, the new algorithm would always be testing the next best possible so-

lution. This program is an example of very basic artificial intelligence. According to the broad definition of artificial intelligence, this program is indeed artificial intelligence because it is mimicking human thought and behavior. It solves the 8-tile puzzle game based off logical decisions.

EARTH & SPACE SCIENCE

Does heat affect the ability of ocean water to make waves? AARON ADAMS, duPont Manual High School, 120 W. Lee St., Louisville KY, 40208.

The purpose of this experiment was to see if water that is warmer and, thus, saltier will make waves as large as the water that is not as salty. The hypothesis was that saltier water would produce smaller waves. The experiment started with different samples of water with a uniform salinity which were boiled for differing amounts of time, to represent different bodies of water that are nearer the equator than others. Salt water was then added to all the samples to even out the quantities of water. This simulated more water running into the ocean as the original water evaporates. Waves were then made by dropping a baseball from a uniform height into the water and the wave height was measured. The process was repeated for all of the samples three times. In conclusion, the hypothesis was supported. The water that was saltiest showed the smallest wave heights. Thus, in theory, water closer to the equator, which is more salty than regular water because of the high evaporation rate, will not produce as large of waves, under the same conditions as water away from the equator where it is less salty.

What angle of slope for a rockslide will result in the greatest tsunami? BEN CANARY, duPont Manual High School 120 W. Lee St. Louisville, KY. 40208.

The problem that was tested in this experiment was the effect of slope angles on a rockslide and the resulting tsunami. This was tested using an apparatus made of a board with a particular slope that would allow for the materials being used to represent a rockslide to roll after they reach the bottom of the slope. The experiment was designed to determine what measure of an angle would be the most dangerous, as far as creating an avalanche. This could be helpful in the scientific world because of the little that is known about tsunamis to begin with, especially where they come from. In the experiment three angles were tested, the angles that were tested lie within the range at which rockslides can be formed. The three angles studied are 45°, 40°, and 35°. The angle that was thought to do the best was the 45°. Logic dictated that it would produce the greatest velocity because of its slope. The other two angles were believed to limit the possibility of the speed at which the material traveled. With the 40° angle, the material was thought to not pickup enough speed as the 45° would, and the trajectory of the rockslide coming off the slope wouldn't be as extreme as the larger angle. The 35° was also not believed to be true because the material would never pick up enough speed to actually go far enough to be the farthest. The results of this experiment

proved the hypothesis correct because the largest angle went the furthest distance and had the most speed. This experiment happened by what was thought, and further investigations into tsunamis and angles of descent will be explored.

Two bioassays for detecting toxic effects of fly ash in soil. LISA SOPER, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Millions of tons of fly ash are produced each year from power plants burning coal. Over 80% of this ends up in landfills, possibly polluting the air, water, and land. The purpose of this experiment was to develop two bioassays that could be used to test the toxicity of soil/fly ash mixtures. Mixtures of varying proportions of potting soil and fly ash were made. Water extracts of these mixtures were used in testing. The first bioassay involved germinating radish seeds and measuring root length. In general, root length varied with the concentration of fly ash in the extract. The roots growing in the soil extract were the longest, followed by those in 90:10, 75:25, and 50:50 mixtures. *Daphnia magna* were used for the second bioassay. They were placed in the various soil/fly ash extracts and the extent of movement was observed. With increased amounts of fly ash, little to no movement was noted after several hours. After the bioassays, *Brassica rapa* were planted in mixtures of soil and fly ash in the same proportions as previously. After growing for a week, plants were imaged and height measurements were taken. The plants in the 50:50 mixture barely grew, but those in the lower concentrations of fly ash grew just as well as the controls. It can be concluded that fly ash in high concentrations has a negative effect on plant and animal life. The growth of radish roots and the degree of movement of *Daphnia* can be used to bioassay fly ash toxicity in the soil.

Which agronomic barrier restricts the most erosion? CHARLES TYLER SMITH, duPont Manual High School, 120 W. Lee Street, Louisville, KY 40208.

Three very common and inexpensive soil erosion solutions were selected and the question was asked: "Which agronomic barrier restricts the most erosion?" It was hypothesized that the terraced slope would prevent the most soil erosion, and the control slope, without any barrier, would release the most runoff. The free-rock slope would be second most effectual with the brush last in effectiveness because of the brushes' lightweight. An apparatus was made to act as the slope with a 30-degree incline. It was divided into four columns for four different barriers. The control in column A, terraces in column B, free rock in column C, and brush in column D. A one-quarter gallon of water was slowly poured at the top of the column. The topsoil runoff collected was heated in an oven, separated of the debris, and weighed. The hypothesis was proven correct except that column D, the brush, allowed for more erosion than the control in column A. The data were tested for significance using a *t*-test. Significant differences

were found among the groups with the evidence rejecting the null hypothesis.

Predicting meteorological trends using high and low extremes of past data. JOSEPH YEAGER, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Daily high and low temperatures were obtained for the meteorological station at Standiford Field airport in Louisville, KY for 1948–2001. The lows and highs were separated and the mean and standard deviation for the high and low temperatures for each day of the year were determined over the period. All high and low temperatures more than one standard deviation from the mean were counted by year, with highs more than one standard deviation above the mean being marked separately from highs more than one standard deviation less than the mean, and similarly for lows, resulting in four counts: High Highs, Low Highs, High Lows and Low Lows. All counts were repeated for values more than two standard deviations from the mean. Two of the eight counts performed in this experiment indicated a cooling trend (High Highs, 1-SD and 2-SD) while the other six indicated a warming trend when subjected to a linear regression analysis. However, the two counts that showed a cooling trend as well as two of the other counts gave regression lines that were nearly horizontal, suggesting that the Louisville temperatures remained roughly constant. The Low Lows and High Lows counts for both 1 and 2 standard deviations indicated a strong trend towards global warming, adding to the body of evidence supporting this theory. Statistical analysis showed that only three of the counts had acceptable R^2 values, all of which indicated a warming trend. The effect of the urban heat island effect on this investigation is also unknown.

ENGINEERING

The feasibility of using a high-alumina ceramic as a hard disk substrate material. OLUMAKINDE ADEAGBO, duPont Manual High School, 120 W. Lee St, Louisville, KY 40208.

The magnetic patterns that comprise magnetically stored data are recorded in a very thin media layer on the surface of a hard disk platter; the bulk of the material of the platter is called the substrate and does nothing but support the media layer. To be suitable, a substrate material must be rigid, easy to work with, lightweight, stable, magnetically inert, inexpensive and readily available. The most commonly used material for making platters has traditionally been an aluminum alloy, which meets all of these criteria. It was hypothesized that a high-alumina ceramic would have less vibration at higher speeds because of its increased rigidity and density. The hypothesis was tested by forming the material into that of a hard drive substrate and mounting on a hard drive motor. It was spun and accelerometer readings were taken from the closest point to the motor. This was compared to readings taken from the original disk to measure the level of change between the two materials. The hypothesis was not sup-

ported by the results collected. The high-alumina ceramic disc caused more vibration than the original platters. There were a few sources of error that could have skewed the data. For future study, the substrate material could be tested at high speeds and under better conditions.

High flash-point oxygen-fuel inosculation for internal combustion engines. YURIY BRONSHITEYN, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208

The emerging realities of a dwindling global oil supply and ozone layer are putting a premium on vehicles that consume less gas and produce fewer emissions. One simple method of accomplishing this is minimizing the number of combustion impurities in the ambient air being fed into the combustion chamber. However, currently no fool-proof method exists of ensuring that the low flash point pure of oxygen will not trigger a catastrophic flash back chain reaction in the combustion chamber or as it comes into contact with the fuel. This project investigated a possible solution to this problem. The technique consequently developed requires a novel apparatus that is the synthesis of several previously unrelated inventions, primarily from the food preparation industry. The design uses a semi-permeable membrane (for example, an amorphous polymer of perfluorodioxol) as a surface for inosculating fuel and substantially pure (30–40%) oxygen. The fuel is projected onto the membrane from a pipe about 2 cm from the upper membrane surface and the oxygen is projected into the membrane through its lower surface from a compressed air chamber. The membrane then permits oxygen, to which it is permeable, to pass through. The upward thrust of oxygen through the pores combined with the downward force of incoming gasoline, traps the fuel directly above the pores of the membrane. The disproportionately strong pressure from within the pores creates bumps along the fuel surface. Those bumps rapidly turn into hills, sharp peaks, and then pinch off from the surrounding surface and finally close in on themselves to form spheres of fuel, encasing gusts of oxygen. This implementation has the advantage of isolating potentially unstable oxygen molecules from the general environment and keeping oxygen and fuel in direct, controllable proportions to more efficiently dispense fuel and generate combustion. The design has the added benefit of being technologically simple (as opposed to a carburetor) to build and maintain, and being readily installed in a typical internal combustion engine. The fuel-oxygen bubbles produced are kept stable through the regulation of pressure in the reaction chamber. Consequently, a marginal amount of fuel is wasted, much less fuel is actually consumed, and nitrogen-based emissions are drastically reduced.

Development of an attachment for wheelchairs for the safe descent of stairs in emergency situations. SUZANNE BRYCE, duPont Manual High School, 120 W. Lee St., Louisville, Kentucky 40208.

When there is an emergency in any high-rise building, the first measure taken to secure the building is to stop

the operation of all elevators. Anyone who is in a wheelchair cannot exit unless another person stops and carries them downstairs. Since this assistance is unreliable, we created an apparatus to assist wheelchair users down the stairs. This attachment connects to a wheelchair, is easy to move on the landings and does not impede daily usage and storage of the wheelchair. In America, 1.7% of the total population (775,000 people) use a wheelchair. Each year, there are 20,000 new users. Wheelchair usage is not limited to the elderly. Twenty-eight percent of Americans who use wheelchairs are under the age of 60 years. These facts indicate the necessity for the advancement of technology for disabled persons. The IBOT, by Dean Kamen, is an innovative wheelchair that ascends and descends stairs. The IBOT costs \$25,000, which is equal to 83% of the average American's annual income. This new device attaches to the wheelchair already employed. It is less expensive and less of an adjustment for the individual. This modification can be easily and inexpensively retrofitted, even to wheelchairs that are covered under Medicare. This device's projected cost is \$325, only 1.08% of the average American's income. This attachment is capable of safely transporting wheelchairs down stairs in emergencies. The lightweight design and durable materials provide for a long product life.

Quieting model aircraft engines. JASON MOORE, duPont Manual High School, 120 West Lee St., Louisville, KY 40208.

People all over the country fly model aircraft, but there are many others who detest them due to the noise produced by the small engines. Since the noise level of a model aircraft engine exceeds 100 decibels, a simple way to soften this sound needed to be found. This experiment was constructed to see what, if any, material placed inside or around the muffler would quiet the sound emitted. During two trials, two different types of foam, the same length, were wrapped around the opening of the muffler. Another trial involved putting a piece of metal shaped as a cylinder into the muffler and then another trial with foam contained within the metal inside the muffler. During each trial, the engine was run at three-quarters throttle for five minutes. The RPMs and decibels were recorded every 30 seconds. Each of these trials was repeated three times. It was found that the composite and wedge foams that were wrapped around the opening of the muffler had permitted the least number of decibels. Yet, the composite foam actually had the engine decrease in RPMs, meaning the engine wasn't running as well. However, the wedge foam increased the RPMs, meaning the engine was running better. Therefore, if you want performance and sound quality, the wedge foam would be the way to go.

Modifications of a Fresnel solar concentrator. JESSICA OTTEN, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of this experiment was to determine whether a lightweight and inexpensive Fresnel solar cook-

er could be designed for potential use in Third World countries. The design was modified from that of Richard Steenblik, the inventor of the coiled Fresnel reflector. A spiral reflector about 2×2 feet was constructed from styrofoam, glue, cardboard, and a mylar reflective material commercially used in blankets for camping. After the cooker was built, the focal length of about 20 cm was located with the use of heat lamps. When tested indoors by means of temperature probes interfaced to a computer, the temperature of water positioned in the focal region indicated greater heating action there than outside the focal area. On February 9, 2002, a sunny day permitted outdoor testing with the same computer interface system. The reflector increased the water temperature greatly compared with its control. Temperature changes of up to 15°C in 20 minutes were obtained even on a cold day. The extent of temperature increase in a given time interval rose through the late morning, peaked, and then decreased after the early afternoon.

ENVIRONMENTAL SCIENCE

Further studies of oil removal by human hair. MARGUERITE BLIGNAUT. Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Previous research has shown human hair to be an effective absorbent of motor oil. The purpose of this work was to test the reusability of hair in absorbing oil. This experiment was done using three types of hair (A, B, and C) that had been studied in previous research. Switches of each type was repeatedly used for absorbing oil, with excess oil mechanically pressed out after each run. All three types of hair proved reusable as absorbents, but the respective samples were only 54%, 63%, and 51% as effective as when clean. The physical characteristics of the original hair were still important because the more oil the hair absorbed originally, the more it absorbed upon reuse. Although reusing hair after mechanically pressing made it less effective than using clean hair of the same type, reusing C hair (the most effective) was as good as using clean B and more effective than clean A. Reusing type B was as effective as using clean A hair. Qualitative observations suggest that the ability to reabsorb oil is still related to physical surface features which are modified in use.

The long-term effects of heavy metal and acid pollution on water quality and soils. SCOTT MOORE, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Nature has been shown to possess a great ability to heal itself of contamination and pollution. However, many forms of pollution simply overwhelm this ability. From 1994 to 1996, Metalite Corporation of New Albany, IN illegally released high levels of heavy metals and acids into an adjacent stream. Although legal action stopped the pollution, the health of the stream is still in question. Indeed, the entire system of environmental enforcement-based on punitive, ex post facto rather than preventive measures,

is in question. The purpose of this research was to evaluate the long-term effects of the Metalite pollution on the water quality of the adjacent stream. To accomplish this, a number of indicative field and lab tests were carried out at upstream and downstream sites. A reference stream was also used to evaluate the field tests in the context of surrounding streams. The analyses performed are as follows: temperature, pH, dissolved oxygen, nitrate content, phosphorous content, chloride content, and total suspended solids. Temperature and pH reflect the general environment of the stream; extreme levels in either parameter can cause death in aquatic organisms. Dissolved oxygen measures the amount of oxygen available to organisms in the stream; the nitrate and phosphorous assays can also reflect the amount of oxygen available. Chloride content is a general indicator of human impact, and total suspended solids can affect cellular performance. In addition, a habitat survey was conducted to put the water quality measures in perspective; if the habitat is deficient, water quality will not be a good indicator of biological activity. Soil analyses for mercury, cadmium, and lead were also carried out on bank sediment samples to examine residual heavy metal contamination. Results were mixed. Dissolved oxygen levels, while higher than those of the reference stream, were higher at the downstream site than the upstream site. Temperature ranges did not exceed normal ranges given atmospheric conditions, nor did pH levels vary significantly. In terms of lab assays, phosphate, total suspended solids, and chloride levels were higher upstream than downstream. Nonetheless, most downstream data exceeded concentrations for normal streams. Total dissolved solids, nitrates, and conductivity, however, were all higher at the downstream location. Interestingly, all of these measures are key indicators of industrial pollution, especially nitrate levels, a major source of which are metal plating industries. Soil sample analysis revealed elevated concentrations of lead, but relatively normal amounts of mercury and cadmium. Finally, the habitat survey indicated a suitability score of 48% (out of 22 possible points on 13 parameters) for the downstream site, and 23% for the upstream site. In sum, the majority of water quality parameters indicated healthier conditions at the downstream site. However, those most specifically indicative of pollution from metal plating (nitrates, especially) indicated strong residual effects of pollution. Furthermore, high concentrations of lead in the soil near the discharge pipe indicate the continued presence of dangerous toxins in the surrounding environment. Based on this and the elevated nitrate, conductivity, and total dissolved solids levels at the downstream site seem to indicate that pollution continues to affect and toxify the stream.

Utilization of optical brightener as an indicator of non-point pollution sources on Beargrass Creek. CHRISTOPHER REZVANIAN, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Beargrass Creek is a large, historically significant creek that runs throughout the city of Louisville and other re-

gions in Jefferson County. Pollution is constantly an issue and the source of this pollution is somewhat subtle. Certain springs along this creek (located using Geographic Informational Systems) were tested for Optical Brightener (OB) as an indication of possible further pollution. Optical Brightener generally originates in domestic cleaning products to make colors and whites visually brighter. It can be easily detected using a low frequency, long-wave black light. Of the five sites tested, only one, the Cave Spring at Big Rock, returned a positive result for all samples. After finding OB, a fecal coliform test was performed on springs along the middle fork of Beargrass Creek, including Big Rock. Of the two sites tested, Big Rock contained 1000 colonies per 100 mL, as compared to another (which did not test positive for OB) that contained only 77 colonies per 100 mL. This validates the theory that OB can be used as an indicator for other biological and possibly chemical contaminants. Rationale for these results can be found in our conclusion that the residential location and lower altitude of the Cave Spring accounted for access from faulty or leaky sewer lines.

Allotment of phytoplankton which can escape the detrimental effects of ultraviolet radiation: A simulation. DAVID TRUONG, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Phytoplankton, plant-like organisms, drift near the surface of bodies of waters. High-intensity ultraviolet radiation, as that of the Sun's, is extremely detrimental to life. Lacking protective ultraviolet-absorbing layers, which higher forms of marine life possess, all forms of phytoplankton are highly sensitive to ultraviolet radiation, specifically UV-B radiation, because it decreases photosynthetic activity. Because they form the basis of the marine food chain on which zooplankton and all other organisms of the marine ecosystem depend upon for sustenance; there is a concern that, due to pollution and global warming, through increased UV-B irradiance penetrating the ocean surface, phytoplankton communities will be harmed; therefore altering the dynamics of marine ecosystems. This experiment's purpose was to discover the depth at which phytoplankton must swim to escape these harmful effects. A fish tank was filled with saltwater and a glow-in-the-dark star was placed on a height-adjustable apparatus. A black light was hung over the, turned on for one second, and the period of which the star produced a "glow" was recorded. The apparatus was then lowered three inches and the experiment was repeated; then lowered and done once more. Two additional trials were performed. Once the experiment was finished, calculations were made to see if the hypothesis of 33 m being the minimum depth to escape the radiation and 40% being the allotment of phytoplankton affected was correct. In conclusion, about 15 m would be the approximate minimum depth to escape the radiation, affecting only under 20% of the phytoplankton population.

MICROBIOLOGY

Attempts to control biofilm formation. JULIE DUNCAN, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Three sets of 9 slides each were placed in 1500 mL beakers inoculated with the alga *Phormidium*. Each set had 3 control (uncoated) slides, 3 slides coated with Rain X, and 3 slides coated with Rain X Anti-Fog. RUN 1 was in direct sunlight for 118 days, and RUN 2 and 3 were kept in dim light for 54 days. The level of light passing through three sets of microscope slides was analyzed to determine the effect of Rain X and Rain X Anti-Fog on the growth and development of biofilms. There were significant differences ($P < 0.05$) between the values for the control and the treated slides. It was found that slides coated with Rain X or Rain X Anti-Fog allowed a much higher level of light to pass through them than the controls. This leads to the conclusion that there is a lower level of biofilm growth on the slides coated with Rain X or Rain X Anti-Fog than those untreated. When horizontal slides were tested, there was actually less growth on them. This was unexpected, mainly because it would seem easier for growth to accumulate on a horizontal surface.

Lytic activity in response to genetic transformation. BRITTANY L. JAMISON, Lewis County High School, Lyons Lane, Vanceburg, KY 41179.

Four groups of *Escherichia coli* were grown and infected with T4 coliphage to determine if the transformation process has any effect on the strength of the cell membrane. The *E. coli* that is genetically altered with the protein will have a higher mean plaque count than that of the unaltered bacteria. Plates were observed for lytic activity for 5 days. The 4 groups were *E. coli* cultured onto medium containing no ampicillin, *E. coli* grown onto a medium containing ampicillin, *E. coli* that had been genetically altered with a green fluorescent protein and cultured onto ampicillin and *E. coli* that had been genetically altered with the protein and cultured onto medium containing no ampicillin. The *E. coli* was transformed through the process of cold calcium chloride treatment. Each transformed plate was cultured from a broth of 10 μ L of plasmid. Every plate was infected with 1 mL of coliphage containing a solution of 150,000 virions of T4 coliphage. The mean plaque count for the transformed bacteria was 24.5, the mean plaque count for the unaltered bacteria was 16.25. The transformed *E. coli* cells appeared to have a weaker cell membrane than the membranes of the unaltered cells. The breaching of a cell membrane to allow new genetic material into the cytoplasm weakens the membrane, resulting in a weaker immunity to bacterium and virus.

The effect of temperature on the rate of induced apoptosis of the cell Lin HL-60. TERESA JUE, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

This study was to determine if temperature would affect the rate of induced apoptosis in HL-60 (Leukemia) cells.

Two different environments were used to run this study. One environment was an incubator, set with 37°C and 5% CO₂, to imitate the environment of a human body. The other environment was room temperature, approximately 20°C with CO₂. One sample was divided after centrifuging and was separated into the two samples used in the experiment. Both samples contained 5 mL of 15% fetal calf serum with HL-60 cells and 5 mL without, making a total of 10 mL in each sterilized flask. The cells were counted through a light microscope with the aid of a hemocytometer and the average was found for a sample and multiplied by 10⁶ to use as the average for 10 mL. Every 12 hours the cells were counted until the cells set in room temperature had almost all died. The cells set in room temperature underwent apoptosis at a rapid pace. Most cells had died within 96 hours; the cells set in the incubator continued to grow at a rapid pace but by 96 hours, the number of cells had plateaued. These results show that the hypothesis was not supported. According to statistical analysis, the data was significant to the 85th percentile, showing that further testing is needed to verify this data. This study does not incorporate other cancerous cell lines or specific temperatures, both of which can be studied further.

The effect of cookware on bacteria growth. MEGAN McGLONE, Lewis County High School, Lyons Lane, Vanceburg, KY 41179.

Cookware can be a good medium for bacterial growth and eventually trigger some food-borne diseases. This experiment was designed to test the hypothesis that stainless steel cookware will be the most resistant to bacterial growth than other types of cookware. In this experiment, six different types of cookware were tested by cooking chicken in them. All the pans were washed and then tested for bacterial growth by using petri film. After the results were gathered, the hypothesis was not supported by the data. The results showed that there was a significant difference in bacterial growth on the type of cookware tested.

Synchronization versus sensitization of prostate cancer cells by curcumin. DAVID MEIGOONI, Paul Laurence Dunbar High School, Lexington, KY 40513.

The effect of curcumin as a sensitizer of radiation on PC-3 and DU-145 prostate cancer cells had been previously investigated. However, no definite explanation for the enhancement of the radiation effect by curcumin has been offered. The goal of this project is to investigate if curcumin is sensitizing the prostate cancer cells through synchronization to a certain cell phase. For this determination, the percentage of the PC-3 and DU-145 cells at various phases of the cell cycle were measured as a function of time for four different treatment modalities: radiation alone, curcumin alone, combination of radiation and curcumin, and untreated. The number of the cells in different phases of the cell cycle were determined using flow cytometry. The results of this investigation indicate that

for both the PC-3 and DU-145 cells, treated with radiation alone, there is a reduction of the cells in the G₀-G₁ phase, which suggests an induction of synchronization of the cells to the G₂-M phase. Furthermore, in PC-3, these results indicate that the presence of curcumin prior to the radiation treatment eliminates the G₂-M block and hence makes the PC-3 cells more radiosensitive. However, in the case of DU-145, the presence of curcumin will increase the G₂-M block, and hence the cells are less radiosensitive. These results are in agreement with the colony forming assay data, which shows an addition of 4-μM of curcumin to PC-3 and DU-145 cells increases their sensitivity by a factor of 8 and 1.14, respectively.

The effect of the genetic structure of cells on their survival fraction. JOHN MEIGOONI, Morton Middle School, Lexington, KY, 40502.

Prostate cancer is one of the most commonly occurring diseases in men over 50 years old. Radiation therapy is one of the most commonly used treatment techniques. The amount of radiation for this treatment is determined based upon clinical experiences. However, prostate glands of different patients are composed of various cell lines with different genetic structures. For example, PC-3 and DU-145 are two types of prostate cancer cells. The purpose of this project was to investigate the effect of the genetic structure of the prostate cancer cells on their survival fraction. This helps to estimate the amount of radiation needed to treat a cancer patient by evaluating the genetic structure of his prostate gland. In this project, the genetic structure of the cells was compared to the survival fraction of the cells after irradiating and counting the cells. The cells were plated in 25-cm³ flasks and were stained after 14 days from the radiation treatment. The ratio of the number of colonies counted to the number of cells plated multiplied by the plating efficiency was used to obtain the survival fraction. A linear-quadratic model was used to analyze the survival fractions for each treatment. The results of this investigation have shown that for a 2Gy radiation the survival fraction for PC-3 and DU-145 were 0.129 and 0.623, respectively. This data showed that PC-3 cells are more sensitive to the radiation than DU-145, which indicates that the genetic structures of the two cell lines did have an effect on the results of this project.

Correlations between heavy metal and antibiotic resistance in bacteria. ANDREW THAI, duPont Manual High School, 120 W. Lee Street, Louisville, KY 40208.

The effects of 7 heavy metals (copper, zinc, silver, cesium, gold, mercury, and lead) and 6 antibiotics (ampicillin, erythromycin, furacin, kanamycin, nalidixic acid, and tetracycline) on 10 different bacterial strains were studied. The selected strains were *E. coli*, *K. pneumoniae* ssp., *P. mirabilis*, *S. typhimurium*, *S. flexneri*, *P. aeruginosa*, *B. megaterium*, *S. salivarius*, *M. luteus*, and *S. epidermidis*. Sensitivity to the heavy metals and antibiotics was tested by the Kirby-Bauer disk diffusion susceptibility test. The most effective heavy metal was zinc (15.7 mm) and the

most effective antibiotic was tetracycline (6.5 mm). All tested gram-negative bacteria were resistant to erythromycin. Every tested bacteria displayed resistance to the gold, silver, copper, and lead samples. Kanamycin and cesium have very comparable inhibition zones (5.5 mm and 4.4 mm, respectively) for all bacteria. The results did not support the hypothesis that antibiotics and heavy metals would not exhibit similar inhibitory effects. Sensitive bacterial strains tended to allow great inhibitory effects, while resistant strains tended to hinder inhibition. *B. megaterium* was the most sensitive to heavy metals and antibiotics. *P. aeruginosa* was the most resistant to heavy metals and antibiotics. The average radius of antibiotic inhibition was directly correlated with the average radius of heavy metal inhibition ($r = 0.74$). These correlations were consistent throughout the results, despite the individual properties of each heavy metal and antibiotic and, more notably, the fundamental distinction between heavy metals and antibiotics.

The effect of mold count on student absentees. KODY WILLIS, Lewis County High School, Lyons Lane, Vanceburg, KY 41179.

Molds surround us everyday which cause allergies or asthma. The purpose for conducting this experiment was to find out if there is a correlation between mold count and student absentees. Our hypothesis was that if the mold count is increased then the number of student absentees will increase. Mold levels were checked by placing petri film in eleven different places in Lewis County High School. Petri film was placed on the ceilings and walls. After a 2–5 day waiting period, the number of mold colonies and the student absentees were counted to see if there is any correlation. The results showed a 0.237 correlation between mold count and student absentees. By doing this study, the hypothesis was found to be incorrect.

PHYSICS

Model membrane biophysics: An Atomic Force Microscopy study of synaptic vesicle fusion. VINITA M. ALEXANDER, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

Neurotransmission depends on the fusion of synaptic vesicles, which carry and release neurotransmitters. The SNARE protein complex (syntaxin, SNAP-25, and synaptobrevin) has been called the “minimal machinery” necessary for fusion and neurotransmitter release. Some contend the SNARE-complex is the true “minimal machinery.” Others find it hard to reconcile the speediness of neurotransmitter release with the slowness implicated in the major conformational rearrangements for SNARE-complex assembly. If the SNARE-complex is established as the major machinery, it will be targeted by drug delivery systems to prevent failure of neurotransmitter release that causes such disorders as paralysis. Atomic force microscopy (AFM) is ideal for nanoscale investigations since it can detect intermolecular forces and can operate under physiological liquid conditions. A biotinylated liposome

suspension of model synaptic vesicles was prepared by sonication of 1,2-dioleoyl-*sn*-glycero-3-phosphocholine (DOPC), 1,2-dioleoyl-*sn*-glycero-3-phosphoethanolamine (DOPE) [with 5% 1,2-dipalmitoyl-*sn*-glycero-3-phosphoethanolamine-N-(biotinyl)], brain sphingomyelin (SM), and 98% pure cholesterol (CH) in a 35/30/15/20 molar ratio. Polyethylenimine (PEI), 5% biotin-PEG-CO₃-NHS (biotin, N-hydroxysuccinimidyl poly(ethylene glycol) carbonate), ImmunoPure® Streptavidin, and the biotinylated liposomes were adsorbed onto AFM silicon (Si) ultralevvers. Biotinylated liposomes were also adsorbed onto a pre-coated Streptavidin slide that was the substrate in an AFM assay. Since past studies of simpler model systems have yielded adhesion values of about 10 nN (10,000 pN), the average force found in this fusion of model synaptic vesicles was expectedly higher at 26.835 nN (26,835 pN). These findings will be considered in subsequent studies when SNARE proteins are reconstituted into model synaptic vesicle systems to ultimately deduce whether the SNARE proteins are major force contributors in biological synaptic vesicle fusion.

Light intensity as a function of fiber diameter, bend diameter, and number of loops. BORIS D. CHERNO-MORDIK, duPont Manual Magnet HS, 120 W. Lee St., Louisville, KY 40208.

This experiment dealt with the relationship between the diameter of the optical fiber, the diameter of bend and number of loops the fiber was subjected to, and the light intensity emitted from the end of the fiber. The light intensity (lux) emitted from the end of an acrylic fiber was measured with a VWR Traceable digital light meter. A 200 W light source was used to provide the light. A fixture was used to hold the fiber and the light sensitive pad at a certain distance, eliminating possible discrepancies caused by varying light measurement conditions. The light intensity was measured for each bend diameter (150, 100, 50, 25, and 15 mm), and for each number of loops (1, 3, 5) at each diameter. Four acrylic fibers were used, each with a different diameter (from 0.5 to 1.5 mm). As the bend diameter decreased, the light loss increased. Furthermore, the experiment showed that a smaller fiber (in respect to diameter) loses less light than a larger fiber at any given fiber diameter. The results suggest that in cases of bending stress, optical fiber bundles are the answer for greater light intensity. If there is not a lot of stress for bend, then one fiber with a greater diameter is an acceptable solution. This experimentation does not answer why it is that a larger fiber loses more light than a smaller fiber when both are subjected to the same bend diameter.

Observing Brownian motion. RACHEL COHN, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

When a tiny particle is immersed in liquid, it is bombarded from all sides by the molecules of the liquid around it. As the molecules collide with the particle, they transfer energy, moving it in random directions. This ran-

dom movement is known as Brownian movement. The average distance a particle moves in a given time interval can be estimated from a formula that requires the particle radius and the temperature and viscosity of the liquid in which the particle is immersed. Polystyrene microspheres of size 1 μm were immersed in distilled water and the displacement was recorded for timed intervals of 15 and 60 seconds. The average of the size displacement measurements was compared with the theoretical distance calculated from the displacement formula. In the equation, the theoretical mean squared displacement for a microsphere after 15 seconds was 6.31 μm . The actual microsphere traveled a mean squared distance of 4.80 μm . In the 60 second time interval, the theoretical displacement was 12.6 μm and the actual displacement was 10.9 μm . Both of the actual displacements for the 15 and 60 second intervals were lower than the equation's theoretical displacement. There are factors that need to be controlled or eliminated to rectify the results. Capillary forces and fluid flow between the microscope slide and cover slip and inaccurate measurement of the particle in a three-dimensional plane could have led to the discrepancies. Once the factors causing error are eliminated, it would be possible to determine the viscosity of any liquid based on the displacement of a particle immersed in it.

The effect of differing leading angles in planform design upon lift and airfoil efficiency. LYLE GOODWIN, Lewis County High School, Lyons Lane, Vanceburg, KY 41179.

The research, specifically described as being of aerodynamic nature, was conducted to ascertain whether leading wing angles (when viewing an airfoil from above) had any effect upon the flight characteristics of a flying wing design at low velocities. The original research hypothesis, only partially supported by the results, was that the two wing designs with less sweep in either direction (22.5°) would perform more efficiently than those with severe sweep (45°), pertaining to both forward and rearward swept designs. To test the hypothesis, five airfoils were constructed of materials as similar as budget would allow (all of the same wood from the same lot). These were placed in a 105 cm diameter wind tunnel, with a 115 V, 1750-RPM fan, capable of producing approximately 30 km per hour winds, with pressure and temperature maintaining near constant throughout the process. They were allowed free movement in a purely upward manner to measure lift. Qualitative measures determined performance. The results shown by the trials showed that the means of the lift measures were negligibly different, but that performance showed a bell-shaped pattern, with 22.5° forward swept wings at its apex.

Effect of ozone on textiles. ANGY MOUNIR, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Ozone is located near the planet's surface in the region known as the troposphere and has a destructive side. It is known to react with other molecules causing severe dam-

age to living tissues of plants and animals. Little research has been done on the effect of ozone on textiles. Pezelj and Cunko (2000) indicate that the strength and quality of propylene fibers are significantly affected by ozone exposure. The purpose of this experiment is to determine how cotton, polyester, and rayon textile thread samples are affected by exposure to ozone. A force probe attached via a LabPro interface connected to a computer was used to measure the initial breaking strengths. The threads were then exposed to ozone for 2, 10, and 25 hours. The breaking strengths of the threads after exposure were recorded and the averages compared to those of untreated fibers. The cotton weakened significantly after all 2 and 10 hour exposures. Polyester was not affected. The breaking strength of rayon thread was not affected by the 2-hour run, but was lowered after 10 and 25 hours.

The effects of wheel diameter and board width on a kickflip. PHIL M. SPRAWLS, duPont Manual High School, 120 W. Lee St., Louisville, KY 40208.

One of the most important and commonly executed tricks in skateboarding is the kickflip. This maneuver is a full rotation of the board, with the rotational axis parallel to the length of the skateboard. The purpose of this experiment was to determine, using physics, how much more difficult it is to perform a kickflip with a bulkier board setup. It was hypothesized that the smaller board setup would take less energy to make the rotation. To measure the difference in energy used, the moment of inertia needed to be calculated for each board setup. The moment of inertia is found by multiplying the mass of each particle in a rigid object by its radius to the axis of rotation squared ($I = mr^2$). This moment of inertia is directly proportional to the work needed to rotate an object. "I" was calculated by using a physics equation for each of the four parts of the skateboard: the board, the wheels, the upper trucks, and the lower trucks. It was found that it would require 61.6% more work to do a kickflip on the bigger board than the smaller board. Future work will try to make a more accurate representation of this figure by adjusting the formulas to better fit the situation.

Coefficient variation of ailerons through changing. JOHN WRIGHT JR, duPont Manual High School, 120 W. Lee St. Louisville, KY 40208.

As the workhorse for today's demanding transportation needs, the airplane functions as both a vehicle for humans and a carrier for their cargo. With today's ailing economy, low cost transportation is a must. Efficiency, aside from security, is the biggest issue plaguing the industry. In previous research, it was found that Riblets, tiny, spanwise grooves carved into the 25+% chord area of the airfoil, created the greatest lift/drag ratio. Further experimentation on Riblet shapes revealed that, though riblets in general provide better lift/drag ratios than traditional airfoils, specifically U-shaped grooves provide the greatest ratio. This year's research tracked the stall rate of ailerons through increasingly higher angles of attack. The

intention was to find the angle of attack, which produces the greatest lift/drag ratio. It is believed that an angle of about 3° would be the best choice.

ZOOLOGY

The effect of *Astragalus* on cholesterol level and heart mass in a *Rattus* model. MELISSA BRADLEY, Science Department, Lewis County High School, Lyons Lane, Vanceburg, KY 41179.

Astragalus is a Chinese herb used to treat poorly functioning immune systems. The purpose of this experiment was to measure the effect of *Astragalus* on the *Rattus* model in cholesterol levels and/or heart mass. Because the rodents have similar anatomical structure compared to humans, findings from this research may indicate a need to do further testing on humans using the herb. Six *Rattus* were separated into three groups of two. Each group was treated with an allotted amount of *Astragalus* twice per day

by an oral gavage for a period of 50 days. The rats were then placed in 2% concentration isoflurane chamber at the laboratory for 15 minutes to incapacitate them. While still unconscious and receiving isoflurane from a gas mask, the *Rattus* were individually removed from the chamber and 1.5 ml of blood was removed by a syringe directly below the xiphoid process. The *Rattus* were immediately terminated by a 0.5 ml injection of Euthasol. The decrease in cholesterol concentration as the *Astragalus* dosage increased was significant. The *Astragalus* did not cause a significant change in the heart mass. Observation *post mortem* revealed unexpected damage to the lungs of the experimental groups. Further investigations should be conducted to discover the cause of deterioration of lung health in the treated *Rattus* and the mechanism effect on the cholesterol. Possible ways to improve future investigations include testing a larger sample size, using higher dosages of *Astragalus*, and examining the liver function.

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